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NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 510

HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS FOR SURFACE SHIPS

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NOTE

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CHAPTER 510

HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS FOR SURFACE SHIPS

SECTION 1.

INTRODUCTION

510-1.1 SCOPE

510-1.1.1 This chapter contains a description of the operation, care, and maintenance instructions for heating, ventilating, and air conditioning systems and their component parts (excluding fans, refrigerant plants, and piping systems). Instructions for the operation, maintenance, and care of fans are contained in **NSTM Chapter 512, Fans.** Instructions for the operation, maintenance, and care of air conditioning chilled water plants are contained in **NSTM Chapter 516, Refrigeration Systems.** A detailed discussion of Physiological Heat Exposure Limit (PHEL) curves, the Wet Bulb Globe Temperature (WBGT) index, and their use in high temperature spaces to prevent heat stress, will be found in OPNAVINST 5100.19C, **Navy Occupational Safety and Health Program Manual for Forces Afloat, Appendix B2** .

510-1.2 SYSTEMS

510-1.2.1 GENERAL. Heating, ventilating and air conditioning systems provide air within the ship that is safe for personnel to breathe and work in. The three separate segments of the system are briefly described in the next three paragraphs.

510-1.2.2 VENTILATION SYSTEMS. Ventilation supply systems take air from the weather and deliver fresh air inside the ship. Ventilation exhaust systems take stale and hot air from inside the ship, and exhaust the air overboard.

510-1.2.3 HEATING SYSTEMS. Heating systems heat ventilation supply air as the air is brought into the ship. Heating systems are also used to increase space temperatures during the heating season.

510-1.2.4 AIR CONDITIONING SYSTEMS. Air conditioning systems cool spaces within the ship. In some cases, ventilation supply air is also cooled as it is brought into the ship.

510-1.3 GENERAL DAMAGE CONTROL

510-1.3.1 HVAC (Heating, Ventilation, and Air Conditioning) arrangements aboard ship are closely involved with damage control and watertight integrity. Damage control classification of the ventilating systems, air conditioning systems, accesses, fans, and closures, are covered in **NSTM Chapter 079 Volume I, Damage Control - Stability and Buoyancy.** HVAC operation during firefighting is covered in **NSTM Chapter 555, Shipboard Firefighting.**

510-1.4 GENERAL SAFETY PRECAUTIONS

510-1.4.1 Safety precautions must always be taken when operating or working on heating, ventilating, and air conditioning systems and equipment. Before performing maintenance or repairs, personnel shall make certain that all equipment in the system or portion of the system to be worked on is properly secured and tagged OUT OF SERVICE. Spaces where toxic gases or fumes might be present shall be certified ″gas-free″ before entering, in accordance with **NSTM Chapter 074 Volume 3, Gas Free Engineering.** Follow precautions on the Planned Maintenance System (PMS) cards. When removing or installing an item of equipment or section of duct, do not stand under the equipment or duct when it is suspended from handling equipment (chain falls and other rigging equipment). Handling equipment shall not be used unless it is known to be adequate for the intended use. In addition, the precautions cited in **NSTM Chapter 300, Electric Plant - General,** for electrical equipment; in **NSTM Chapter 505, Piping Systems,** for steam piping systems; and in **NSTM Chapter 516, Refrigeration System,** for refrigerant systems, shall be understood and followed.

510-1.5 DEFINITIONS

510-1.5.1 GENERAL. The following terms and definitions briefly describe the processes and terms used in providing HVAC aboard surface ships.

510-1.5.2 AIR CONDITIONING. The process of treating air in order to control its temperature, humidity, cleanliness, and distribution to meet the design criteria for a particular space or compartment.

510-1.5.3 AIR FILTRATION. The process of removing air impurities, such as contaminants, grease, dust, vapors, fumes, and smoke.

510-1.5.4 BLOW-OUT AIR. Air used to purge potentially contaminated air in compartments not normally ventilated or to provide weather air to magazines manned during general quarters to limit CO_2 build-up to safe levels. Closures on the blow-out air ductwork are opened before personnel enter the space, and the closures are shut after personnel leave the space.

510-1.5.5 CLEAN AIR. Air that has been filtered to remove CBR (chemical, biological, radiological) contaminants.

510-1.5.6 CLEAN SIDE. That part of the CPS (Collective Protection System) supply system that is downstream of the CBR or HEPA (high efficiency particulate air) filter bank (i.e., that portion of the CPS supply system which is always supplied with clean, filtered air) (see Figure 510-5-1).

510-1.5.7 COLLECTIVE PROTECTION SYSTEM. The Collective Protection System (CPS), as defined for HVAC systems, consists of a combination of specially equipped, integrated supply and exhaust systems designed to protect certain zones within a ship from airborne chemical, biological, and radiological contaminants. Collective Protection Systems may be either Total Protection (TP) or Limited Protection (LP) systems. (See TP and LP System definitions.)

510-1.5.8 DEHUMIDIFICATION. The process of removing moisture from the air. Onboard ship, this is done by condensing moisture on a cooling coil (either by an air conditioning system or by a mechanical dehumidifier) or by use of a desiccant such as silica gel.

510-1.5.9 DIRTY AIR. Air that has not been filtered to remove CBR contaminants.

510-1.5.10 DIRTY SIDE. That part of the CPS supply system upstream of the CBR or HEPA filter bank (i.e., that portion of the system exposed to air that has not been through the CBR filter) (see Figure 510-5-1).

510-1.5.11 DRY BULB TEMPERATURE (DB). The temperature of air in a given location as measured by a thermometer with a dry sensor shielded from radiation (the sun or hot surfaces).

510-1.5.12 FLOODING WATER LEVEL (FWL) I. The highest water level that can be expected at any particular intact main transverse watertight bulkhead, when that bulkhead serves as a confining boundary to flooding after any flooding that the ship is expected to survive.

510-1.5.13 FLOODING WATER LEVEL (FWL) II. The highest water level that can be expected above the bulkhead duct at any particular intact watertight subdivision, after any flooding elsewhere in the ship that the ship is expected to be capable of surviving.

510-1.5.14 HEATING. The process of adding heat to air to maintain the desired temperature within the interior of the ship.

510-1.5.15 HUMIDIFICATION. The process of adding moisture to the air.

510-1.5.16 LATENT HEAT. Energy that is added to air that does not change its temperature. In Navy use, it is the energy required to evaporate water into air.

510-1.5.17 LIMITED PROTECTION SYSTEM (LP). A Collective Protection System designed to prevent solid or liquid CBR agents from entering a CPS zone. This is done by providing limited filtration of biological and chemical aerosols and radioactive fallout by use of a prefilter (roughing) followed by a HEPA filter. Personnel in spaces protected with LP systems must wear gas masks when operating in a CBR environment. No other CBR protective clothing is required while in LP spaces. An LP system does not provide for pressurization of served spaces. The LP system provides partial protection against CBR contamination.

510-1.5.18 PRECOOLING. The cooling of weather supply air with cooling coils. This is a type of air conditioning.

510-1.5.19 PREHEATING. The heating of ventilation and replenishment air as it is brought into the ship from the weather.

510-1.5.20 PRESSURE ZONE (PZ). A section of the ship protected by a TP system that is pressurized to a pressure of at least 2.0 inches water gage above atmospheric pressure to prevent infiltration of CBR contaminated air. A pressure zone must have dedicated supply and exhaust fans. It must be capable of maintaining pressure without the supply of air from other pressure zones.

510-1.5.21 RECIRCULATION SYSTEM. A system consisting of a fan and those components of the HVAC system that provide air conditioning to a space or group of spaces by recirculating and tempering (i.e., in heating or cooling) the air within the space(s). Normally, a recirculation system is not connected to the weather.

510-1.5.22 REHEATING. The heating of air supplied to a space or group of spaces to maintain specific design conditions within the space.

510-1.5.23 RELATIVE HUMIDITY. Relative humidity, a measured index of the moisture content of air, is the ratio of the quantity of water vapor present in a volume of air to the greatest quantity of water vapor that can be absorbed by that volume of air at a given temperature.

510-1.5.24 REPLENISHMENT AIR. Weather air that is supplied to spaces, compartments, or recirculation systems to maintain acceptable air quality within the ship.

510-1.5.25 SENSIBLE HEAT. Heat that is associated with a change in temperature. In Navy use, it is the energy added or removed from air to change the air temperature.

510-1.5.26 TOTAL PROTECTION SYSTEM (TP). A Collective Protection System designed to prevent solid, liquid, or gaseous CBR agents from entering a CPS zone. This is done by filtering all incoming air and by pressurizing the ship's interior with high pressure fans. The filtration is accomplished by prefilters (roughing filters), followed by HEPA filters and charcoal filters. The area protected by a TP system is pressurized to prevent air infiltration that could contain CBR contamination.

510-1.5.27 TOXIC GAS DAMPER. A device that prevents toxic gases from missile launching from entering ventilation supply systems. The damper is a closure that is shut prior to weapon system firing, and opened after the threat of ingesting toxic gases is over. Toxic gases resulting from the firing of weapons systems can enter the ship through the ventilation system and pose a hazard to personnel. Dampers are provided at or near the weather opening of selected vital ventilation supply systems in order to prevent the bulk intake and distribution of toxic gases into the ship.

510-1.5.28 VENTILATION. The process of supplying weather air to a ship's interior while, simultaneously, exhausting ship's air. Ventilation may be accomplished by natural or mechanical means or a combination of both. Ventilation air may or may not be tempered (heated or cooled).

510-1.5.29 WET BULB GLOBE THERMOMETER INDEX. The wet bulb globe thermometer index (WBGT) is an index for determining whether or not conditions of heat stress exist in a manned compartment. The index is measured with a globe thermometer, a dry bulb thermometer, and a mechanically ventilated (aspirated) wet bulb thermometer. The three components of the WBGT index are related, mathematically, as follows:

WBGT index = 0.7 WB + 0.2 GT + 0.1 DB

Where:

WB = wet bulb temperature

GT = globe thermometer reading

DB = dry bulb temperature

The WBGT meter and OPNAVINST 5100.19C are used to determine if shipboard heat stress conditions are present.

510-1.5.30 WET BULB TEMPERATURE (WB). The temperature measured by a thermometer with a sensor which is closely fitted with a water-moistened wick and which is shielded from radiation (the sun or hot surfaces). The wet bulb temperature is used with the dry bulb temperature to determine the relative humidity of the air being measured.

510-1.5.31 ZONE. A group of spaces, each of which has approximately the same heat gain, concurrent load variations, and delivery air temperature requirements.

510-1.5.32 ZONE HEATING AND COOLING. The use of a single reheater or cooling coil to serve a group of spaces each of which has approximately the same exposures, use, concurrent load variations, and delivery air temperature requirements.

510-1.6 HVAC FOR PERSONNEL

510-1.6.1 The purpose of heating, ventilating, air conditioning, and other environmental control is to maintain a crew that is physically fit and mentally alert. HVAC provides an atmosphere that will enable the body to maintain proper heat balance, air that has a sufficient oxygen supply, and air that is free from harmful components. On surface ships, requirements for odor and temperature control result in a supply of outside air in excess of that required for oxygen renewal (2 cubic feet per minute of fresh air, per person). This air quantity should not be assumed to be capable of removing hazardous vapor and gas spills, such as Freon and carbon tetrachloride. OPNAVINST 5100.19C contains information on preventing injuries caused by hazardous vapor and gas spills.

510-1.7 HVAC FOR EQUIPMENT

510-1.7.1 Air conditioning or ventilation may be required for ammunition storage spaces to prevent deterioration of ammunition components caused by adverse temperature conditions. Air conditioning or ventilation is necessary in areas containing electrical and electronic equipment to control ambient temperatures so the equipment will operate correctly.

510-1.8 ORGANIZATION

510-1.8.1 On every ship, an organization should be established to operate and maintain the equipment provided for heating, ventilating, and air conditioning. The responsibilities of this organization should include operation, testing, inspection, and maintenance of all HVAC equipment.

510-1.9 DOCUMENTATION

510-1.9.1 The Ship Information Book (SIB) provides data for a specific ship. The Equipment Data Lists that give information on specific components of the HVAC system are referenced in the SIB. A detailed description of equipment used for HVAC systems on surface ships can be found in the **Equipment Manual for Heating, Ventilating, and Air Conditioning** , 0910-LP-432-7800.

SECTION 2.

VENTILATING SYSTEMS

510-2.1 TYPES OF VENTILATING SYSTEMS

510-2.1.1 GENERAL. Ventilating systems are designed to meet strict requirements regarding watertightness, airtightness, cleanliness, maintainability, and repairability. Ventilation ducts that penetrate certain defined watertight boundaries below the Flooding Water Levels (FWL) have watertight closures. Many ventilation ducts which run below the FWL's are designed to be watertight. No alterations to ventilation systems should be made without specific approval from the Naval Sea Systems Command (NAVSEA). **Unauthorized alterations may compromise the watertight integrity of the ship or degrade the performance of the HVAC system.**

510-2.1.2 SUPPLY SYSTEMS. Ventilation supply systems are used to supply weather air to ventilated spaces and replenishment air to air-conditioning recirculation systems. A typical supply system has a weather intake with a screen, an air lift, a preheater, a fan, supply system ductwork, and supply terminals. Other components that may be used on supply systems include toxic gas dampers, blast shields, precooling coils, and watertight closures.

510-2.1.3 EXHAUST SYSTEMS. Ventilation exhaust systems exhaust air from ventilated compartments and remove stale air from areas served with air-conditioning recirculation systems. Exhaust may be accomplished either mechanically with fans, or naturally to the outside atmosphere. A typical exhaust system has an exhaust terminal, exhaust system ductwork, a fan, and a weather discharge with a screen. Air may be exhausted directly from the space ventilated or through spaces such as baths, pantries, or passageways. The air removed by exhaust systems is replaced with air from a supply system. Overheating in a ventilated space is often encountered because the exhaust air path to the outside atmosphere is blocked. If hot air is not removed, the supply system cannot replace it with cooler air from the outside, even though the supply system may be clean, open, and operating.

510-2.1.4 MACHINERY SPACE EXHAUST. The ventilation systems of machinery spaces should be operated to provide a mechanical exhaust air quantity greater than the mechanical supply air quantity (this may not apply to some ships with diesel propulsion that are designed to have a positive pressure in machinery spaces with respect to the weather). This is done to create a negative pressure in the space with respect to the weather. The negative pressure will cause an in-draft of weather air to enter the machinery space through a natural supply (a supply duct with no fan). Supply and exhaust fans in machinery spaces, when operated simultaneously at high or low speeds, maintain the designed amount of excess exhaust air. The exhaust system removes the supply air (adjusted for expansion due to the heat in the space) plus approximately 5 percent extra to ensure in-draft through the natural supply. If there is no excess exhaust, hot air from machinery spaces will be forced through accesses into the ship.

510-2.2 VENTILATION EQUIPMENT

510-2.2.1 WEATHER OPENINGS. Where ventilation systems are fitted with weather covers, the ventilation weather openings subject to ingestion of ″green water″ should be kept open as long as possible in rough weather to permit ventilation with outside air. Some supply systems are designed to permit recirculation of interior air when the weather opening is shut, but this is of little benefit in spaces where heat loads are high and weather air is used for cooling.

510-2.2.2 PROTECTION OF WEATHER OPENINGS. Where it is possible to do so, weather openings of ventilation systems are located in protected positions high up in the ship, under overhanging decks, or on the after side of structures. Openings that must be located where they are exposed to rain, spray, or heavy seas are provided with protection against water ingestion in accordance with the degree of exposure to which they are subjected. This may be done with plenums, air lifts, baffles, moisture separators or other methods.

510-2.2.3 PREVENTION OF WATER ACCUMULATION IN DUCTWORK. Personnel should maintain drains provided in ventilation systems in working condition. These drains are provided in ductwork to prevent accumulation of water in ductwork caused by the intake of spray or condensation in the ductwork. Personnel should verify that terminals are not located where water can drip from them onto electrical equipment such as computers, control panels, electronic equipment, generators, generator terminals, load center and power distribution panels, switchboards, transformer terminals, and similar equipment. If terminals are installed over this type of equipment, this should be reported through the chain of command to NAVSEA, using the Ventilation Alteration Request described in Section 7. Installation of duct sections over electrical equipment is avoided where possible. If duct sections must be routed over electrical equipment, the duct is either of watertight construction or made driptight. Ducts must also be arranged without duct connections or access openings over electrical equipment.

510-2.2.4 SPRAY REMOVAL. Spray removal as a method of providing protection for weather openings may be divided into the following categories:

510-2.2.4.1 Hoods and Baffles. A design which places the weather opening in a more protected position, such as hoods opening downward or aft, away from the direction in which rain or spray is driving or baffle plates placed along the flat surfaces around the opening to interrupt the travel of spray along these surfaces.

510-2.2.4.2 Airlift Types. An airlift draws the weather air upward at a low velocity to permit the entrained drops of water to fall out of the airstream. (See Figure 510-2-1.)

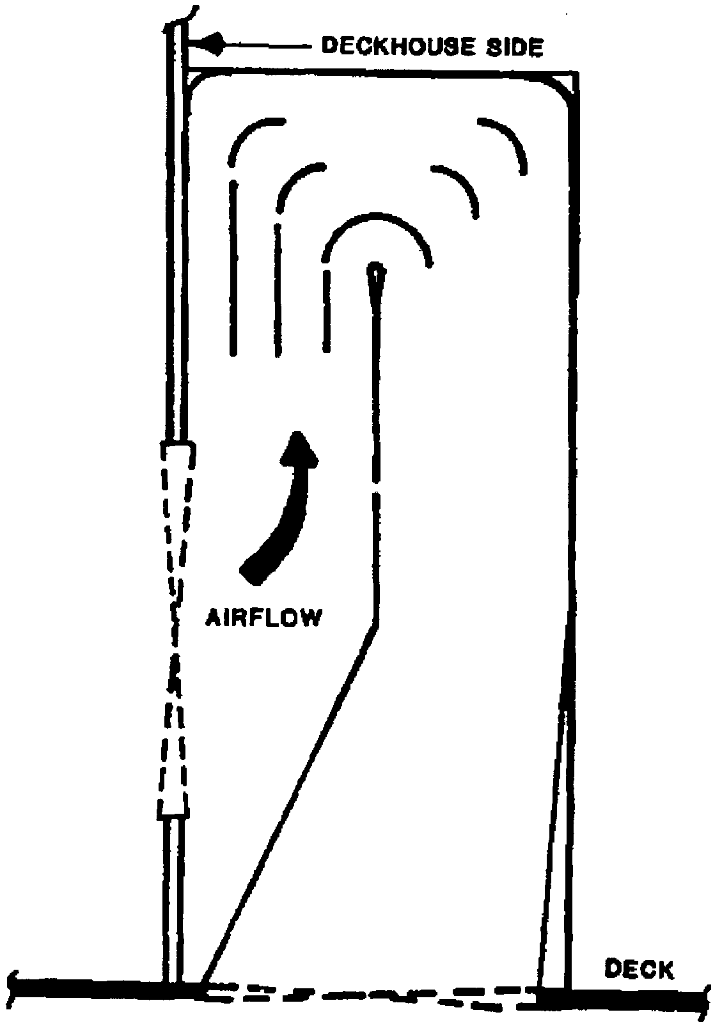


Figure 510-2-1 Ventilation Intake Airlift

510-2.2.4.3 Moisture Separator. This intake design removes water from the weather air by a sudden change in the direction of the airstream. In the moisture separator, baffles change the direction of the airstream several times and cause the water droplets to hit the side of the duct. The water runs down the side of the duct and is drained away. (See Figure 510-2-2.)

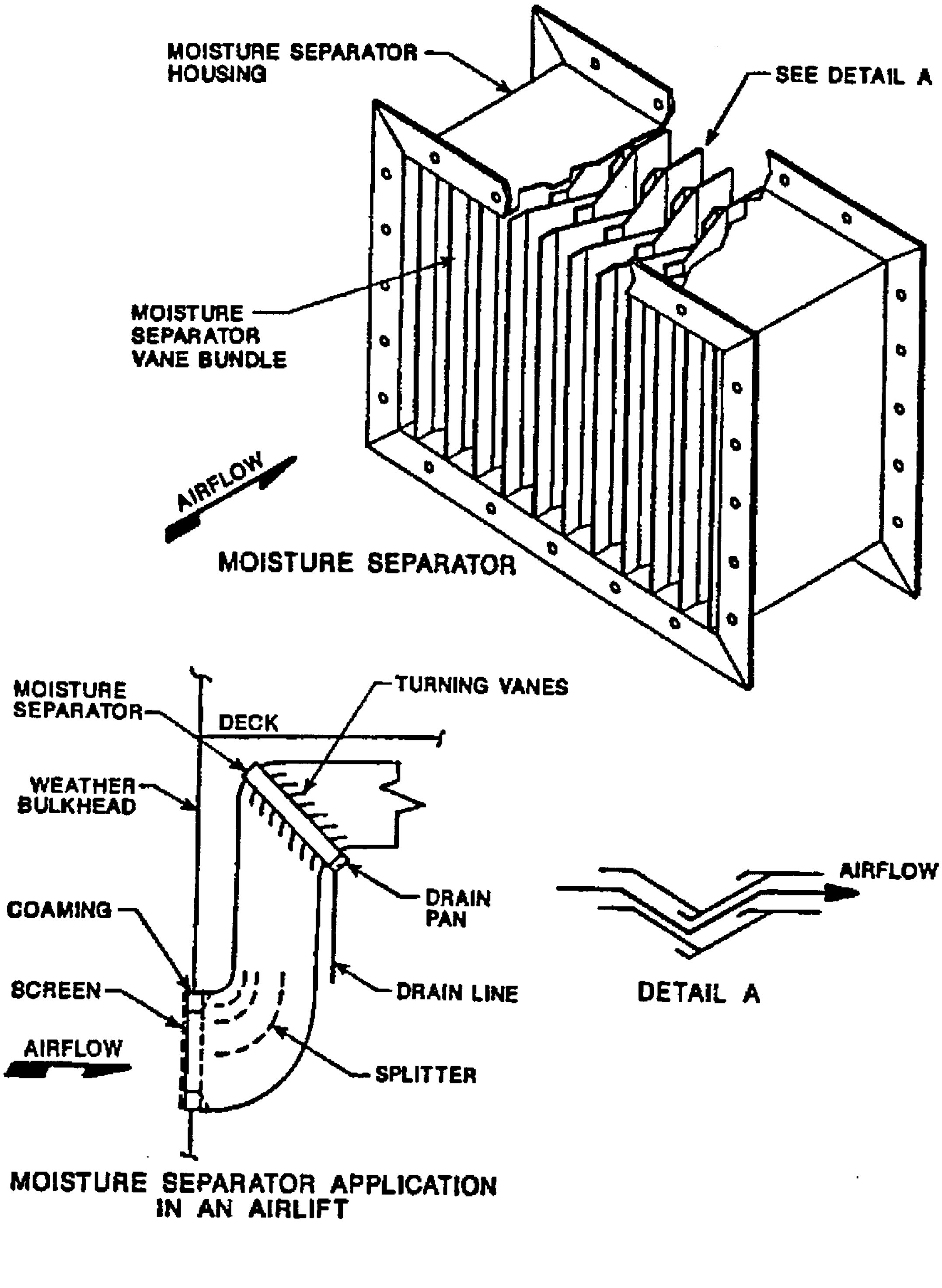


Figure 510-2-2 Moisture Separator

510-2.2.4.4 Mushroom Ventilators. Mushroom type ventilators combine the characteristics of hood and baffle and airlift type intakes. The top of the trunk is surrounded by a mushroom-shaped hood from which is suspended a skirt, surrounding and extending a short distance below the end of the trunk. Air enters between the trunk and the skirt and passes upward. When the trunk extends above the deck, a horizontal baffle plate is provided on the trunk below the skirt to prevent the entry of spray driven up the outside of the trunk.

510-2.2.4.5 Waterproof Ventilators. Bucket type, automatic closure waterproof ventilators may be installed where it is necessary to locate ventilation intakes or exhaust in exposed locations on weather decks to serve spaces requiring continuous ventilation. They are designed for use on the weather deck, where they may be submerged by waves or exposed to heavy spray. The ventilator consists of an outer coaming, an inner ventilator trunk extending up into the outer coaming, and a trap bucket supported over the ventilator trunk by a compression spring. The bucket has a drain tube that extends into the sump between the ventilator trunk and the outer coaming, and the sump is provided with scupper valves draining onto the weather deck. A sectional view of a typical bucket type waterproof ventilator is shown in Figure 510-2-3. While details of ventilators may vary, the essential features of the bucket type waterproof ventilators are:

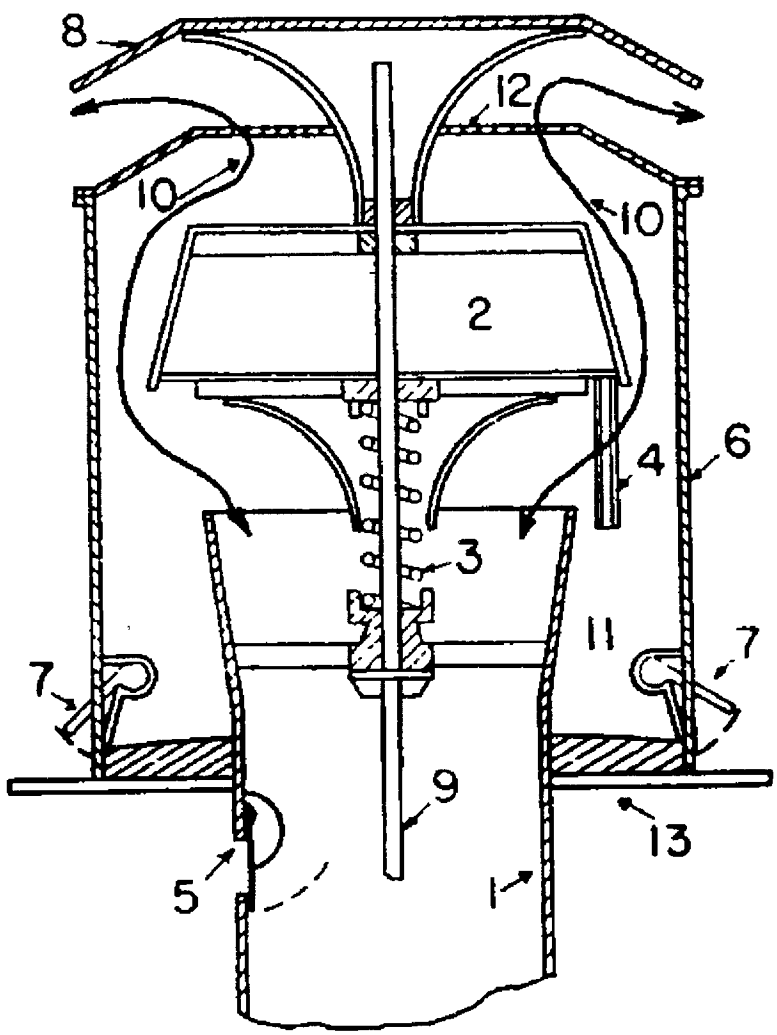


Figure 510-2-3 Bucket Type, Automatic Closure Waterproof Ventilator

a. Ventilator trunk or shaft extending above the weather deck

b. Trap bucket supported by a spring or springs

c. Spring or springs that support the bucket

d. Bucket drain tube

e. Vacuum breaker in the ventilator trunk (can be mounted externally to act as a pressure relief valve on the exhaust trunk)

f. Outer coaming or housing, of heavy gage material to withstand heavy seas, enclosing the upper end of the ventilator trunk and the trap bucket

g. Scupper valves to drain the sump

h. Ventilator top

i. Extension of the trap bucket guide shaft to which operating gear is attached to permit manual closing of the bucket

j. Air passage surrounding the bucket

k. Drain sump outside the ventilator trunk

l. Opening above the trap bucket

m. Weather deck

The ventilators operate automatically and are normally open. Small quantities of water that enter the ventilator fall into the bucket and drain out through the drain tube and scuppers. In heavy seas, when water enters the bucket faster than it drains out through the drain tube, the weight of the water forces the bucket down against the top of the ventilator shaft and forms a watertight seal that is maintained until sufficient water drains out to permit the spring to raise the bucket to the open position. Operating gear is also generally provided to permit manual closing of the ventilator.

510-2.2.5 TOXIC GAS DAMPERS. Toxic gas dampers are installed on ventilation supply systems which have the potential to ingest toxic gases from the firing of weapon systems. The ventilation supply systems with toxic gas dampers are interlocked with the launch controller or salvo warning contactor, so that before the firing of a weapon system that produces toxic gases, the supply fan will be shut down and the toxic gas dampers shut. After firing is complete, a short interval (2 to 5 minutes) is allowed for gases to dissipate. A timing mechanism then opens the toxic gas damper and restarts the fan. The toxic gas damper technical manual contains further information on the operation, repair and maintenance of this equipment.

510-2.2.6 BLAST SHIELDS. Blast shields cover the weather intake on all ventilation systems that could be damaged from overpressures due to firing of the ship's weapon system. The blast shields protect these ventilation systems from blast damage. A typical blast shield is shown in Figure 510-2-4.

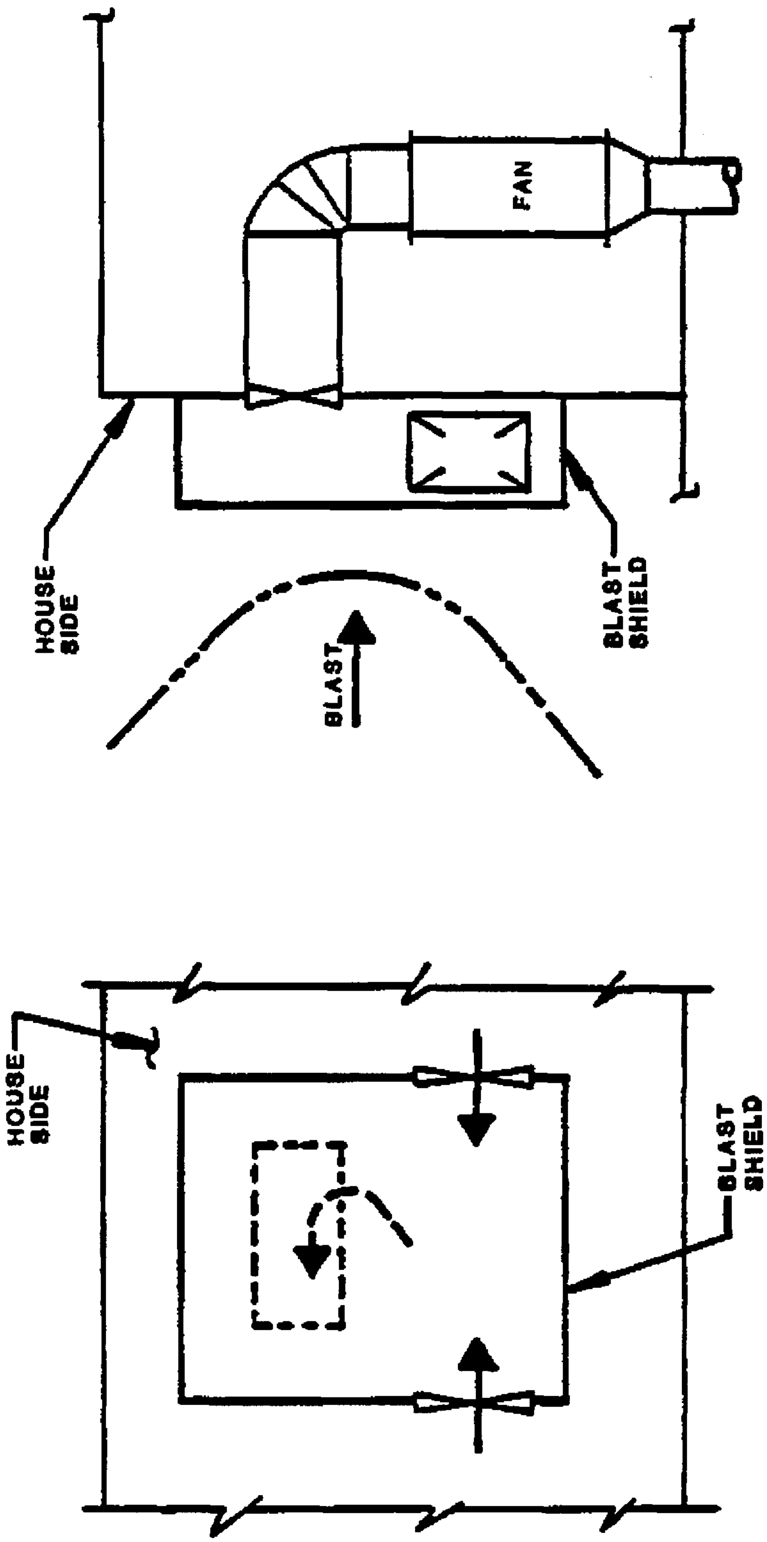


Figure 510-2-4 Typical Blast Shield

510-2.2.7 CLOSURES. Ventilation closures used for damage control (water and smoke containment) should have the same degree of tightness as the deck or bulkhead affected, so that airtightness or watertightness will not be impaired. Closures must be maintained in working order to be effective. Illustrations of closures are shown in Figure 510-2-5 and Figure 510-2-6. Ventilation closures are designed to be quick closing and are usually of one of the following type:

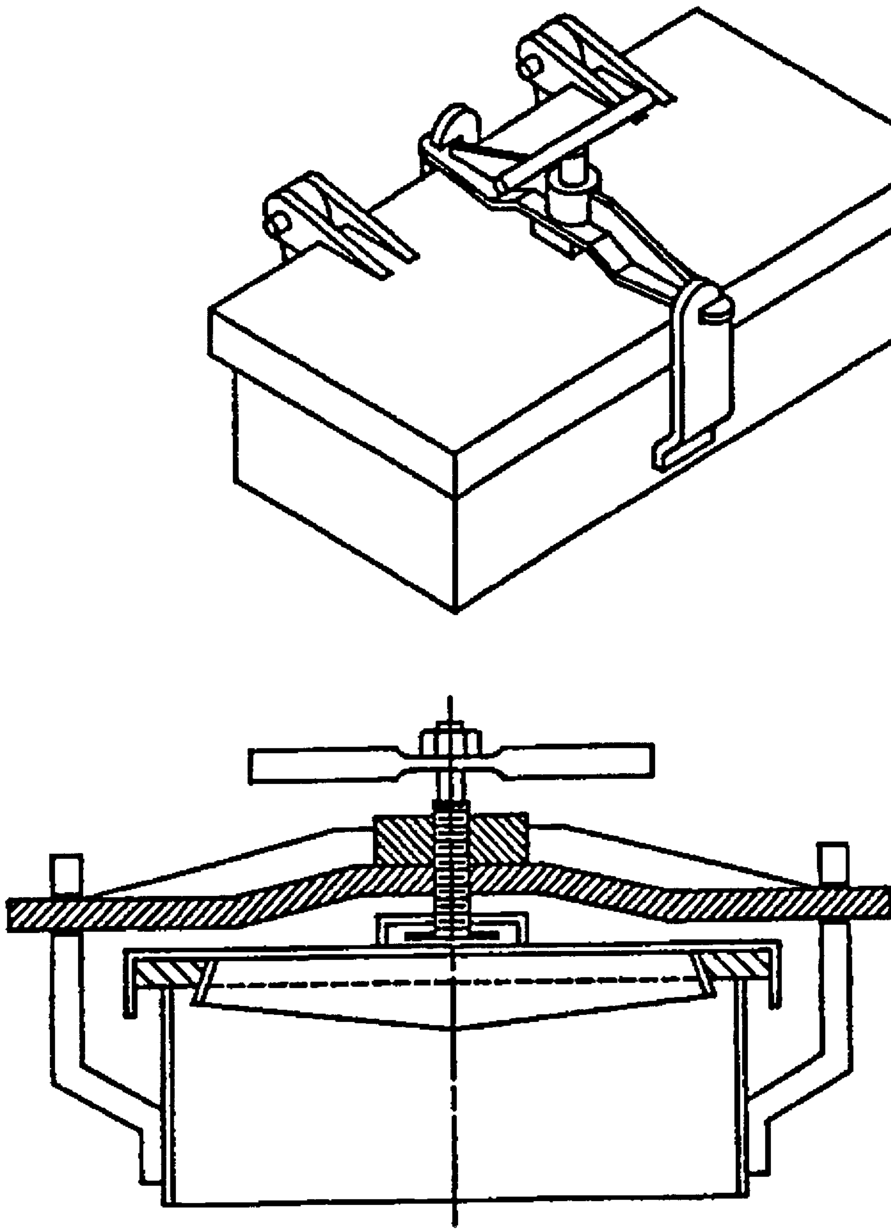


Figure 510-2-5 ″F″ Cover

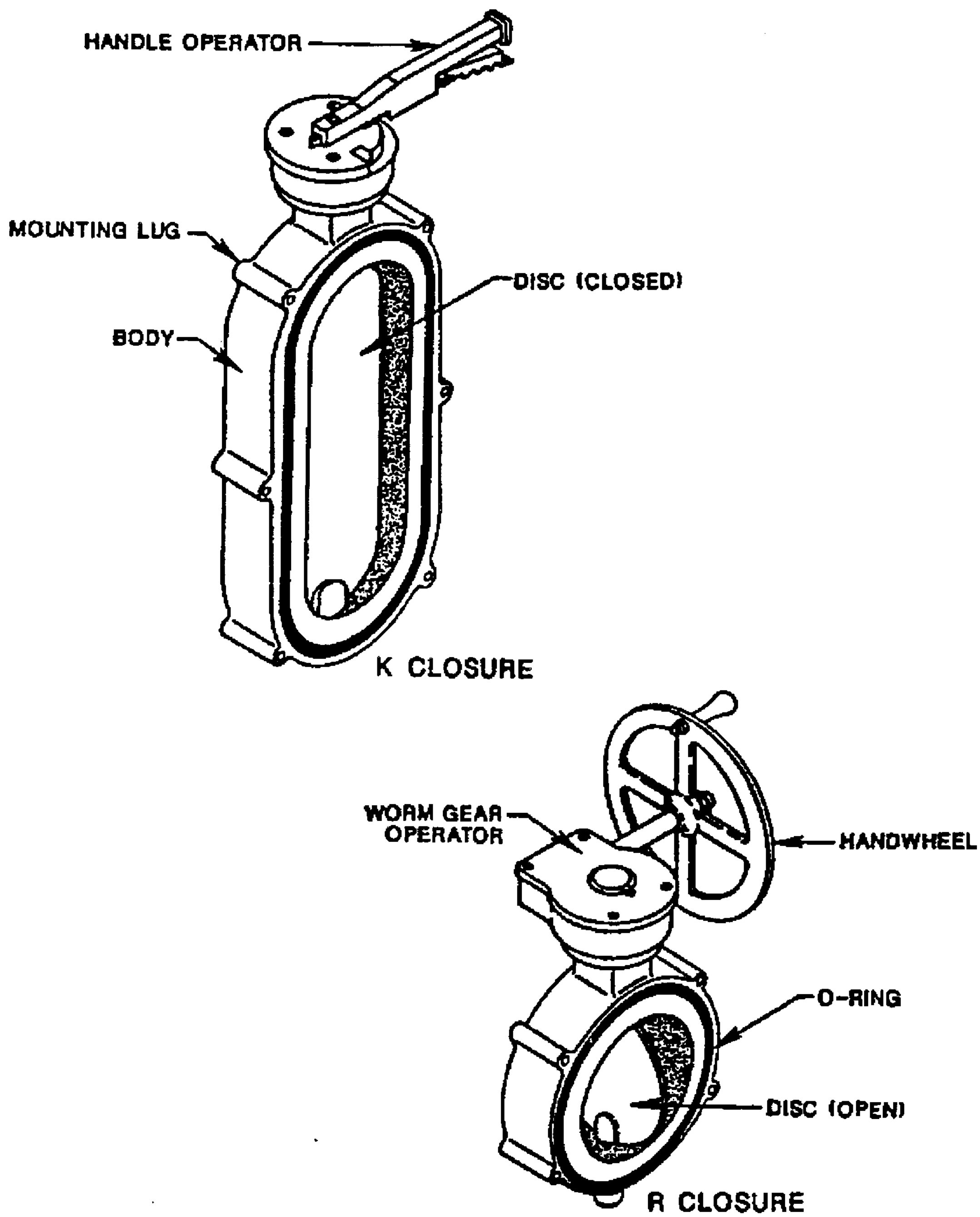


Figure 510-2-6 ″R″ & ″K″ Ventilation Closures

a. **Type F** is employed only at the end of ducts. This arrangement consists of a strongback that swings at the center of the outside of the cover in the plane of the cover, and engages under two hooks attached to the coaming. After the strongback is swung into place, the cover is secured by means of a screw that forms the strongback pivot.

b. **Model K** is a lightweight butterfly valve that is flat oval in shape and is used in flat oval or rectangular ducts. This type of closure may use a handle, a handwheel and worm gear, or an electric actuator to open or close the valve. These closures are typically mounted in ductwork between flanges. Some type K closures are manufactured from stainless steel and may serve as fire dampers.

c. **Model R** is a lightweight round butterfly valve used instead of type A valves. This type of closure may use a handle, a handwheel and worm gear, or an electric actuator to open or close the valve. These closures are typically mounted in ductwork between flanges. Some type R closures are manufactured from stainless steel and may serve as fire dampers.

510-2.2.8 WEATHER CLOSURES. Some weather openings have closures such as type F for protection from water ingestion into systems serving spaces not requiring continuous ventilation, and where a closure is necessary for compartment testing. These closures require the same attention and upkeep as described for interior closures. Closures for mushroom ventilators, when used, are located under the hood and consist of a circular welded steel plate held tight by a locking screw. A molded rubber gasket seats on the trunk extension.

510-2.3 OPERATION OF VENTILATION

510-2.3.1 CIRCULATION. Ventilation air circulation is provided by supply and exhaust ducts and bracket fans. For ventilated spaces, circulation is usually accomplished with distribution ducts and terminals on the supply systems and on the exhaust system. Some exhaust systems may be fitted with only a main exhaust terminal or a bell-mouth opening on the fan. Bracket fans improve the air circulation in ships' working spaces that are not air conditioned.

510-2.3.2 VENTILATION AIR DISTRIBUTION. For machinery spaces, cool outside air is ducted directly to the watch stations, and the intakes of exhaust systems are located as high as possible in the horizontal plane over various principal heat sources. Since hot air rises, locating the exhaust intakes in the overhead is the most effective method of removing heat from the space. In this way, the ventilating air (both supply and exhaust) is used to the best advantage. In small spaces, the supply and exhaust terminals or exhaust openings are generally installed in opposite ends of the space to provide good air circulation. Exhaust hoods are used over equipment that produces fumes or particulates. Hoods may also be used over heat producing equipment. Flexible ductwork is used to exhaust air from welding slabs and other similar equipment. Flex ducts are also used in some helicopter hangars to exhaust hot air from the aircraft cooling system. In spaces where welding operations are conducted, the ventilation system must meet the minimum standards specified in **NSTM Chapter 074, Volume 1, Welding and Allied Processes.** If the ventilation is not adequate, additional temporary ventilation must be provided as noted in **NSTM Chapter 074.**

510-2.3.3 BRACKET FANS FOR CIRCULATION. Bracket fans are 12- inch diameter nonoscillating fans. They are typically bulkhead mounted. The fan has three major parts, the electric motor and bracket, the fan blades and hub, and the fan guard. A bracket fan is illustrated in Figure 510-2-7. In hot weather, bracket fans can provide high local circulation in spaces without air conditioning. Bracket fans should be installed in ventilated issue rooms and workshops. The criteria for selecting the number of fans is as follows: only one fan is provided when the deck area is less than 300 square feet, and an additional fan is provided for each additional 300 square feet of deck area.

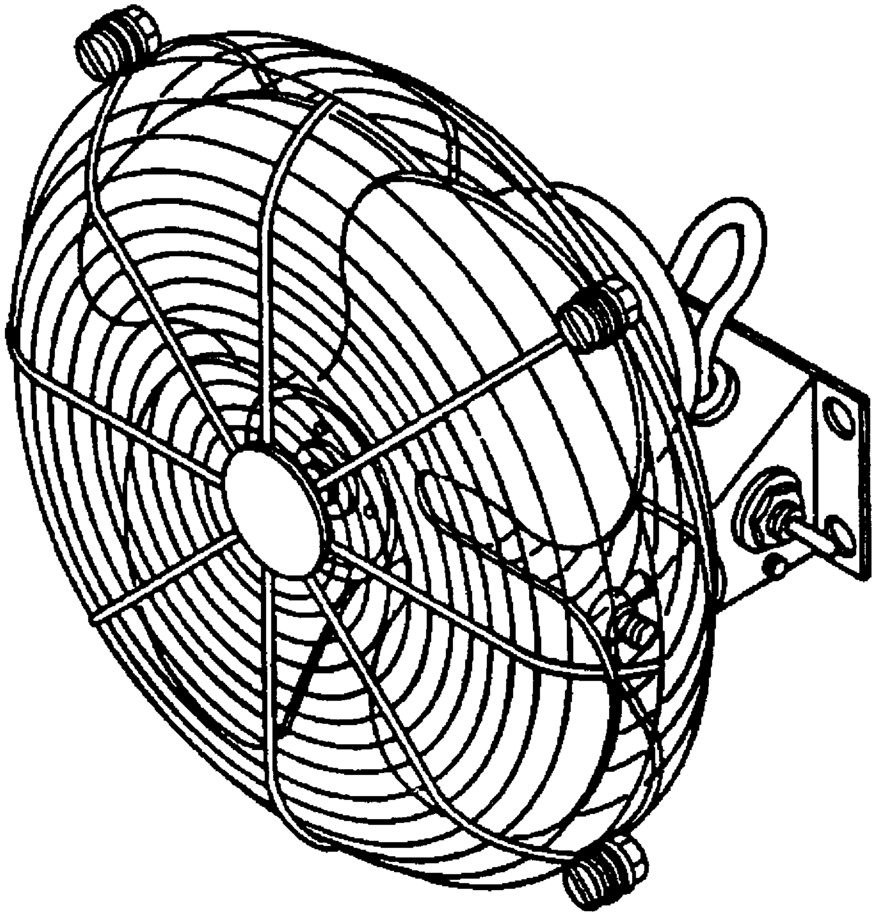


Figure 510-2-7 Bracket Fan

510-2.3.4 BLOWOUT VENTILATION. Some spaces are provided with blowout ventilation. The quantity of blowout air for most magazines is determined by investigating the possibilities of carbon dioxide build-up using the formula: N = 0.0034V, where: V = gross volume of the space in cubic feet. If the number of men in the compartment is equal to or greater than N, the air quantity shall be based on a 10-minute rate of change. If the number of men is less than N, the air quantity shall be based on a 30-minute rate of change. This should be operated for at least 15 minutes before personnel enter the space where watertight closures are classified ″Y.″ It should be kept in operation while personnel are in the space to prevent carbon dioxide build-up. Blowout ventilation should be secured after personnel leave the space. Where watertight closures are classified ″X,″ the blowout ventilation should be operated for only 15 minutes after receiving the DCA’s permission.

510-2.3.5 TEMPERATURE. The temperature within a compartment is raised by equipment and lights in operation within the space, radiated heat on decks and hull, heat transferred from surrounding higher temperature spaces or outside air, and by heat generated by the occupants of the compartment. The temperature rise is limited by the quantity and temperature of ventilating air supplied to the space. The minimum space temperature rise is obtainable only when the ventilation system delivers the design air quantity. Given a constant quantity of heat to remove, and assuming a constant supply air temperature, the temperature rise will be:

$$t_r = H/1.08Q$$

Where:

t_r = temperature rise in the space

H = heat removed from the space in Btu/hr

Q = ventilation air delivered to space in standard cubic feet per minute (cfm), based on standard air conditions

1,08 = conversion constant

Consequently the temperature of the space can be determined by:

$$t_a = t_{sa} + t_r$$

Where:

t_a = temperature maintained in the space, °F

t_{sa} = temperature of supply air, °F

510-2.3.6 VENTILATION AIR COOLING. Many spaces that are not air conditioned are cooled with ventilation air. Ventilation air is brought into the ship from the weather, used to cool a space, and then exhausted to the weather. In working spaces other than boiler and machinery rooms, the difference between space and weather temperatures will not exceed 8.3°C (15°F). Higher temperatures are used in the design of normally unmanned equipment spaces, and in machinery spaces. The minimum temperature differential between compartment and outside temperatures is limited by the volume, space heat load, the weather air temperature, and the space ventilation rate. These factors should be considered when investigating reports of deficient ventilation. A check should be made of the compartment temperature in comparison to the weather air temperature, if deficient ventilation is suspected.

510-2.3.7 SPOT COOLING. In very hot spaces such as main machinery spaces, it is not feasible to maintain a specific ambient temperature throughout the entire space. For such spaces, spot cooling is provided for each watchstander's station. Spot cooling is a high velocity blast of weather air that is directed onto the watchstander. Due to the high velocity, the incoming air does not rapidly diffuse and mix with the room air. This creates a zone of cooler air where the watchstander should be positioned. This system is effective, even at high outside temperatures, as long as the temperature at the watchstander's station is considerably lower than the room temperature. Adjustable blast terminals are provided for spot cooling at watchstander's stations. They should be located within 3 to 5 feet from the watchstander's station and directed so that the air blast will strike the watchstander's torso. The angle of motion of the terminals is restricted so that they cannot discharge in positions where, if water entered through the terminal, electrical equipment might be damaged.

510-2.3.8 OTHER METHODS OF COOLING NON-AIR-CONDITIONED SPACES. Non-air-conditioned compartments directly under the weather deck can be cooled by wetting the deck. Frequent applications of a fine spray of water are more effective than less frequent heavy wettings.

510-2.3.9 PORTABLE VENTILATION EQUIPMENT. When repairs must be made to a piece of equipment located in a hot spot (an area outside the effective area of a permanent supply system terminal), spot cooling can be achieved by using a portable vaneaxial or centrifugal fan (red devil fan) (see **NSTM Chapter 512, Fans**). The portable fan should be set up to draw air from the nearest supply system outlet or the weather and direct it over the repairman while repairs are being made. The inlet ducting of the fan should not be attached directly to the permanent supply system outlet. There should be at least a 1-foot air gap between the supply system outlet and the inlet of the ventilation ducting. Not more than three lengths of flexible ducting should be used with the portable fan.

510-2.3.10 VENTILATION DURING AND AFTER FIREFIGHTING. Excluding machinery spaces, present naval policy (**NSTM Chapter 555, Shipboard Firefighting** ; and **Surface Ship Damage Control** , NWP 62-1) requires that the HVAC system be secured in the area of a fire. For machinery spaces, **NSTM Chapter 555** requires establishing ventilation during a fire (when the Halon system is not in use) as follows:

a. IN AFFECTED MACHINERY SPACE
   1. Set negative ventilation (exhaust on high, supply on low).
   2. On ships with interlocked fans and remote controls with an emergency exhaust button (remotely located in enclosed operating station (EOS) or at access on ships without EOS) set emergency exhaust (exhaust on high and supply off).
   3. On ships with fans interlocked through a local master switch but with independent control on controllers inside the space, set negative ventilation.
   4. On other ships with interlocked fans the ventilation system shall remain operating.

b. IN UNAFFECTED MACHINERY SPACES
   1. Set positive ventilation (supply on high, exhaust off). Setting positive ventilation is intended to prevent smoke on the damage control deck from entering unaffected spaces.
   2. On ships with fans interlocked through a local master switch inside the space but with independent control on controllers, set positive ventilation.
   3. On other ships with interlocked fans the ventilation system shall remain operating.

510-2.3.11 SMOKE CONTROL. Smoke removal is necessary when it has been definitely determined that the fire has been completely extinguished. Natural ventilation and forced ventilation, by the installed ventilation systems or by portable ventilating fans, can be used to clear compartments of smoke and fumes. Before ventilating in any way, however, the following precautions must be observed:

a. Determine that the fire has been extinguished.

b. Investigate HVAC systems to the affected area to make sure they are free from fire or smoldering material.

c. Have fire parties and equipment standing by the fans and controllers of the HVAC system.

d. Obtain the permission of the engineering officer to open HVAC system closures and start fans as required to ventilate the compartment.

Exhaust systems should be used to clear compartments of smoke and fumes resulting from fires. The use of exhaust systems will create an in-draft from adjacent spaces and prevent the smoke and fumes from spreading. Supply systems, if used, normally will force smoke and fumes into adjacent spaces, causing possible smoke damage and further danger to personnel. Smoke containment and removal diagrams are under development for some ship classes. These diagrams provide a pre-engineered, rapid response mechanism for restricting the spread of smoke. The diagrams assist firefighters in determining what actions are required for effective smoke containment and removal. Should ″fallback″ actions be required, the modular zone concept utilized in the diagrams enables subsequent actions to be quickly and easily identified. Repair personnel must be familiar with the ship’s HVAC system to enable them to clear compartments of smoke and toxic fumes following extinguishing of shipboard fires, or other toxic atmosphere-producing accidents. Limitations of recirculating systems for smoke and toxic gas removal must be understood. Exhaust systems are preferable for smoke control because they create an in-draft from adjacent areas and prevent the fumes from spreading, whereas if supply systems are used, the gases may be spread to surrounding inboard areas.

510-2.3.12 SMOKE CONTROL DAMPERS. Smoke control dampers are provided in vital manned spaces in some classes of ships. The dampers prevent smoke contamination of served spaces caused by a fire or smoke outside the space. The dampers are part of the supply and exhaust ductwork of systems ventilating or providing replenishment air to vital manned spaces. Smoke control dampers are also used on air-conditioning systems serving more than one vital manned space, if the spaces have watertight, airtight, or fumetight bulkheads. The smoke control dampers are operated from inside the space served. The dampers shall be shut when smoke begins to enter the compartment from the ductwork.

510-2.4 RELATED EQUIPMENT

510-2.4.1 MAGAZINE CHECK VALVES. Check valves are devices that allow fluid flow in only one direction. These valves are part of magazine air escapes. Air escapes prevent air pressure from building up in the magazine when it is flooded. In many cases, ventilation ductwork is used for the air escape. When ventilation ductwork serves as the air escape, magazine check valves are installed to allow air to escape from magazines into ventilation ductwork during flooding operations. These check valves do not permit anything to enter the magazine through the ventilation duct. The check valves are located in the ventilation ductwork between the watertight closure in the magazine and the magazine bulkhead. These valves are required to allow air to escape when the watertight closures to the magazine are closed when the magazine is flooded.

510-2.4.2 MAGAZINE OVERFLOW CHECK VALVES. Overflow check valves are swing type check valves used in water and air escapes during magazine flooding. These valves permit air or water to escape from the air escape ductwork when the magazine is flooded. These valves do not allow anything to enter the ductwork. The valves are required in air escape ductwork that extends above the V-lines. The valves are installed in a section of air escape ductwork located above the V-lines.

510-2.4.3 INSPECTION OF MAGAZINE CHECK VALVES. Instances have been reported where the check valves have been reversed when installed, thus providing valve operation in the wrong direction. The installation of these check valves should be inspected and the valves removed and properly reinstalled if necessary. When the check valve is of the ordinary swing type, a pipe plug is inserted in the end during compartment testing (see **NSTM Chapter 079 Volume 2, Damage Control - Practical Damage**). Care should be taken to ensure that such plugs are removed immediately after the test.

510-2.4.4 REMOTE OPERATING GEAR. In general, remote operating gear is provided only for magazine closures below decks and fire dampers. Most other closures are locally controlled, and every effort is made to provide accessible locations for the closure operator. When this is not possible, as in some stowage spaces, extension stems are provided to permit operation from the working area of the space or immediately adjacent to the space. All of the gear must be maintained in good operating condition. Clothing and other items must not be stowed in such manner as to foul the operating gear and impede or prevent its operation. Stuffing boxes must be set up tightly enough to maintain the tightness of the bulkhead penetrated, without interfering with the ready operation of the gear. Operating gear of closures and ventilators should be cycled as required by PMS cards.

SECTION 3.

HEATING SYSTEMS

510-3.1 HEATING METHODS

510-3.1.1 BASIC HEATER TYPES. Naval surface ships are normally heated with steam or electric duct heaters, convection heaters, and unit heaters. Duct heaters are installed in ventilation supply system ducts as preheaters or reheaters, and in recirculation system ducts as reheaters. Convection heaters are generally used in spaces not served by mechanical supply systems or recirculation systems. Unit heaters (heating coils with their own fans) are used in spaces as described in paragraph 510-3.2.6.

510-3.1.2 PREHEATERS. A preheater is a duct heater, generally installed near a supply system intake. The preheater heats the intake weather air sufficiently to prevent condensation on supply system ducts within the ship. Otherwise, sweating would occur on the outer surfaces of the cold ducts. The supply duct air temperature after preheating should be in the vicinity of 4.4°C to 10°C (40°F to 50°F).

510-3.1.3 REHEATERS. Reheaters are duct heaters that raise the temperature of the preheated supply or recirculation system air. This is done to maintain the desired temperature in the space(s) served by the reheater. Reheaters are either steam or electric powered.

510-3.2 HEATING SYSTEM

510-3.2.1 GENERAL. Heating systems using duct heaters are usually part of a ventilation supply system or part of an air conditioning recirculation system. Two types of heating systems, zone heating and individual space heating, supply heat to shipboard living and working spaces. The heating equipment should be operated to keep spaces at the temperatures specified by the HVAC System Diagram in the Ship Information Book. Maintaining a compartment at a higher temperature than specified in the SIB during the heating season increases energy consumption.

510-3.2.2 ZONE HEATING. A zone heating system has a single duct reheater serving several spaces. Each zone consists of spaces that are exposed simultaneously to similar heat loss conditions and served by a single reheater. The reheater is controlled by a thermostat located at a point within the zone that is representative of the space conditions to be maintained.

510-3.2.3 INDIVIDUAL SPACE HEATING. An individual space heating system has a reheater for each space served. The reheater is located in the duct leading to the space served or is located at the end of the duct in the space served. In this type of system the reheater for each space supplies the additional heat necessary to compensate for heat loss through boundaries of that space. The reheater is controlled by a thermostat located in the heated space. In some cases, a convection heater is installed in the space instead of a duct type heater.

510-3.2.4 DUCT HEATERS. A Navy standard electric duct heater is shown in Figure 510-3-1. Electric duct heaters are constructed in accordance with military specification MIL-H-22594. Electric duct heaters consist of three or more electrical heating elements. Each element consists of a helically coiled resistance wire centered in a densely packed insulating material which, in turn, is enclosed in a hermetically sealed finned metal sheath. Each end of the element has a threaded stud-type terminal for connecting the element to the electrical power circuit. For safety, the enclosure for the electrical connections, located on the side of the heater casing, is of spraytight construction. The heating element's entrance to the enclosure is also made watertight. Each electric duct heater uses the fan circuit for that system as the power source. Thus, the heater cannot operate unless the fan is operating. This is required to safeguard against fire and heater damage due to excessive heat. Each electric heater has a safety cutout switch that trips when the heating element temperature is excessive. The switch must be manually reset after the cause for the high temperature has been determined and corrected. The steam duct heaters are constructed in accordance with military specification MIL-H-16235. The heating element is made of copper tubing that has been expanded into the heat transfer fins, and has twin steam headers. Steam duct heaters may also be of double construction with an outer copper tube that has been expanded into the heat transfer fins and an inner steam distributing tube with a single header. Steam duct heaters use low pressure steam to heat the air as it passes through the duct heater. A steam duct heater is shown in Figure 510-3-2.

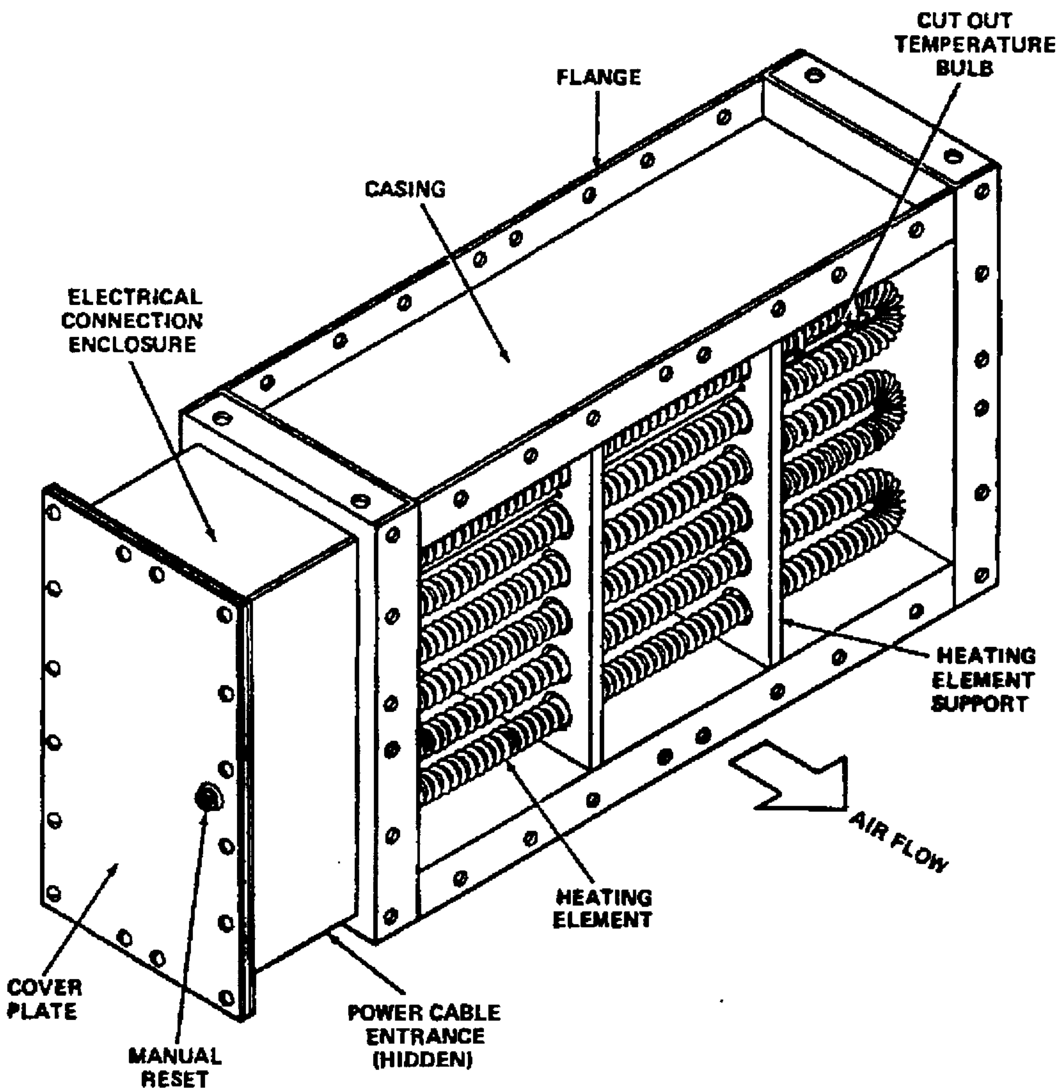


Figure 510-3-1 Duct Heater (Electric)

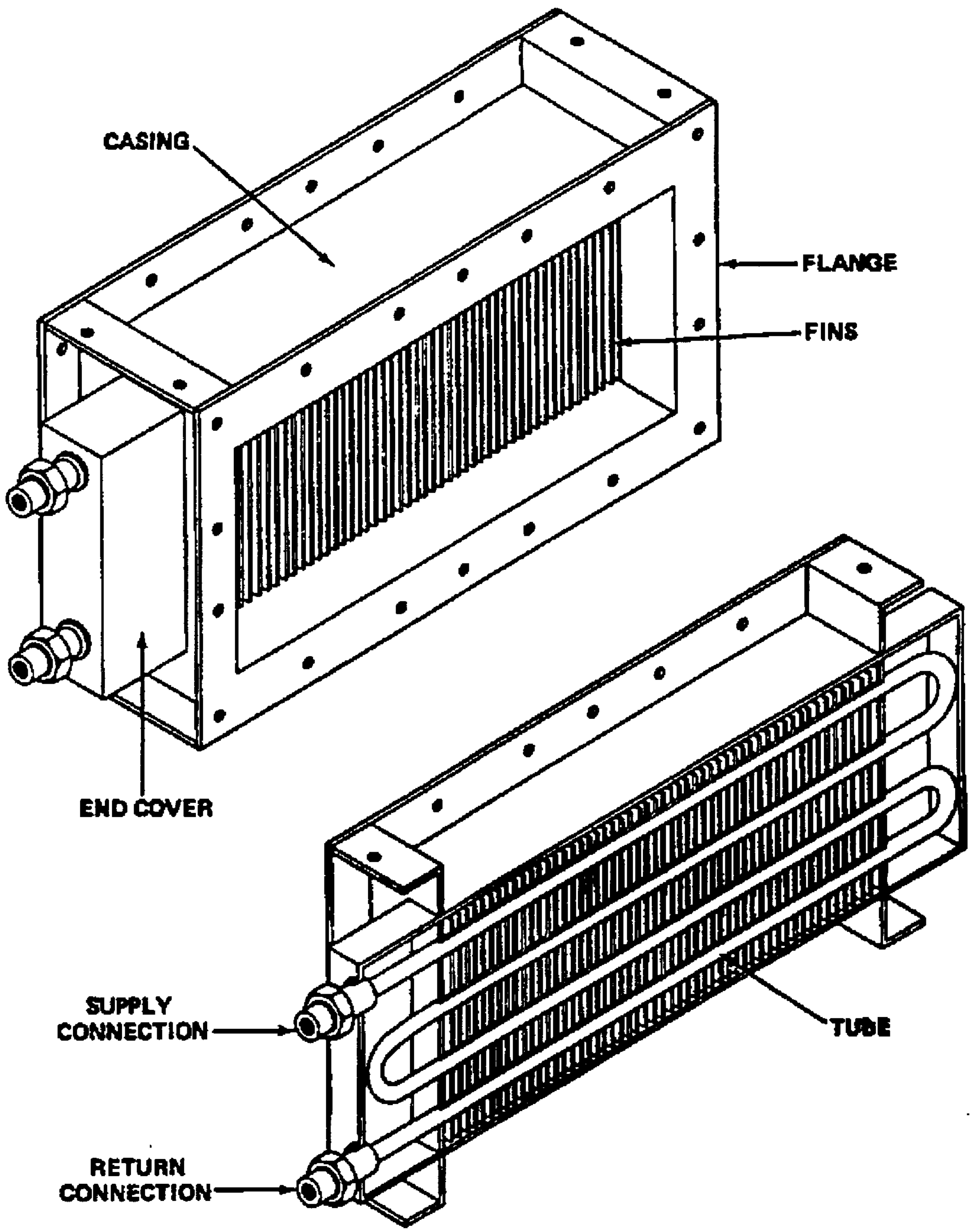


Figure 510-3-2 Duct Heater (Steam)

510-3.2.5 DIRECT (CONVECTION) HEATING. Convection heaters may be provided instead of or in addition to heated air for certain small spaces. Convection heaters are also extensively used to heat spaces that receive indirect ventilation from other heated spaces (washrooms and waterclosets are examples). Convection heaters may use either steam or electricity as an energy source. The Navy standard steam convection heater has an adjustable damper for regulating the temperature in the space. In addition to the adjustable damper, some ships employ an adjustable type R thermostat, which operates a model E temperature regulating valve to regulate the temperature in the space. See Figure 510-3-3 for a typical steam convection heater. See Figure 510-3-4 and Figure 510-3-5 for views of typical electric convection heaters.

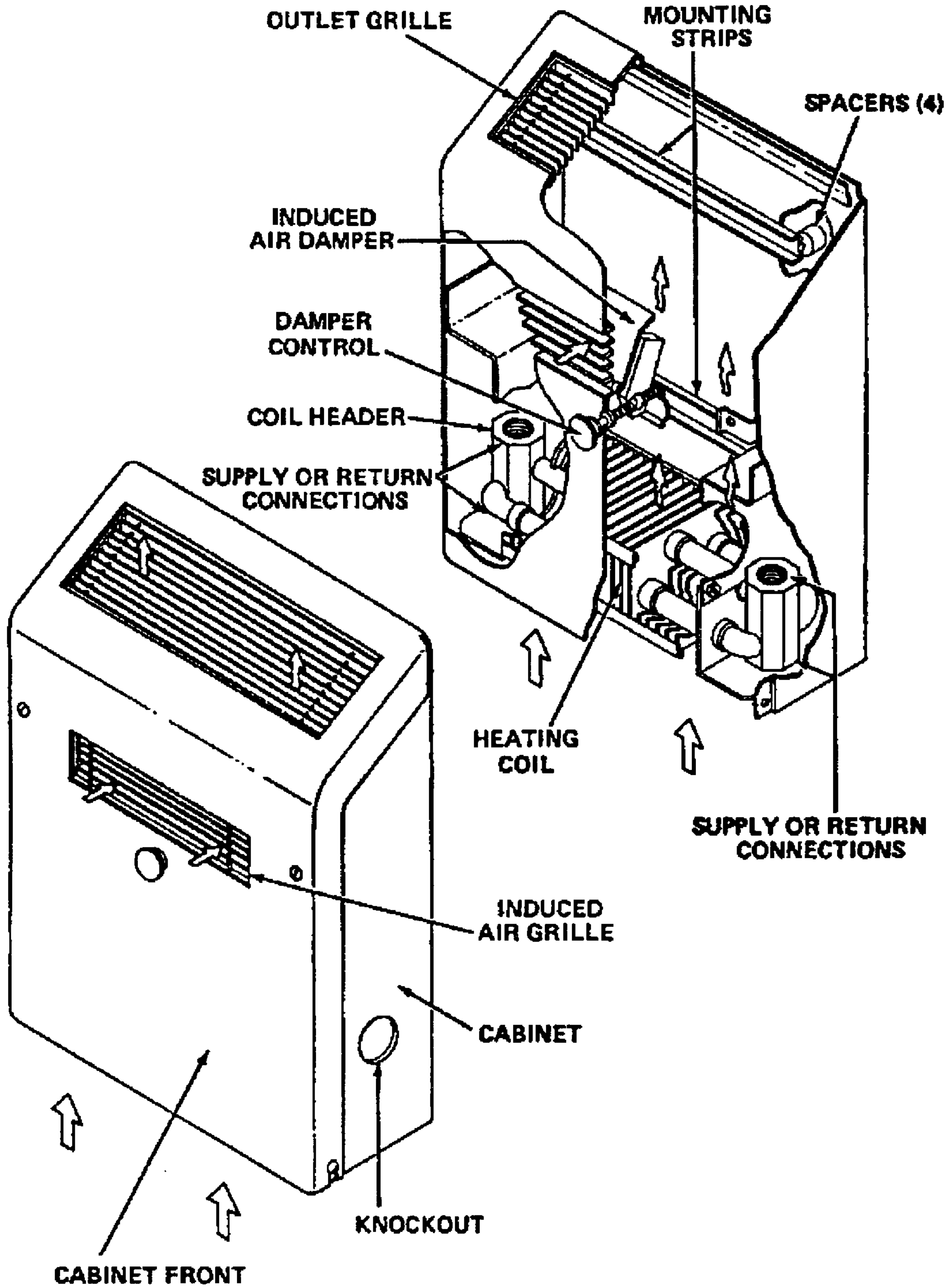


Figure 510-3-3 Convection Heater (Steam)

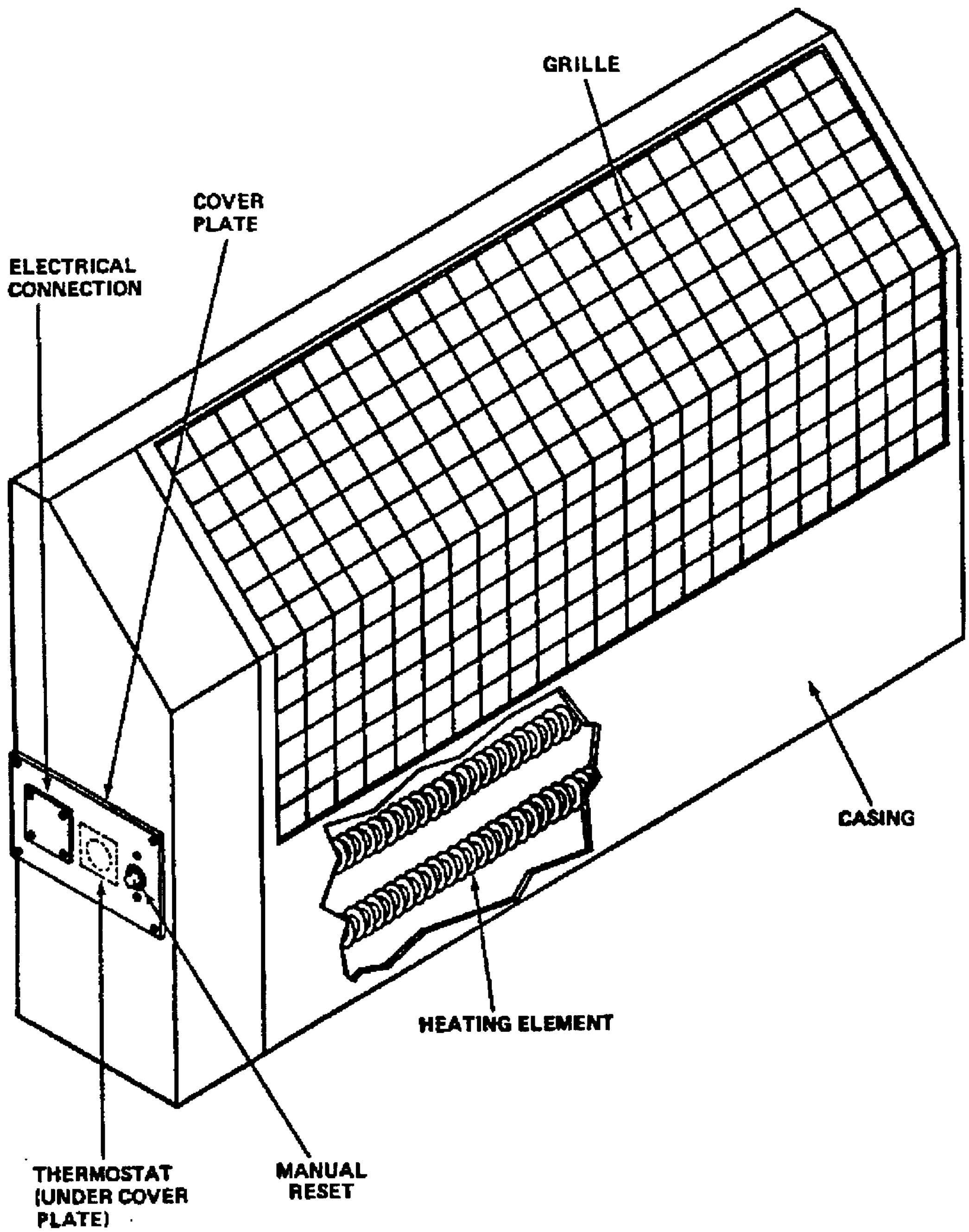


Figure 510-3-4 Convection Heater (Electric)

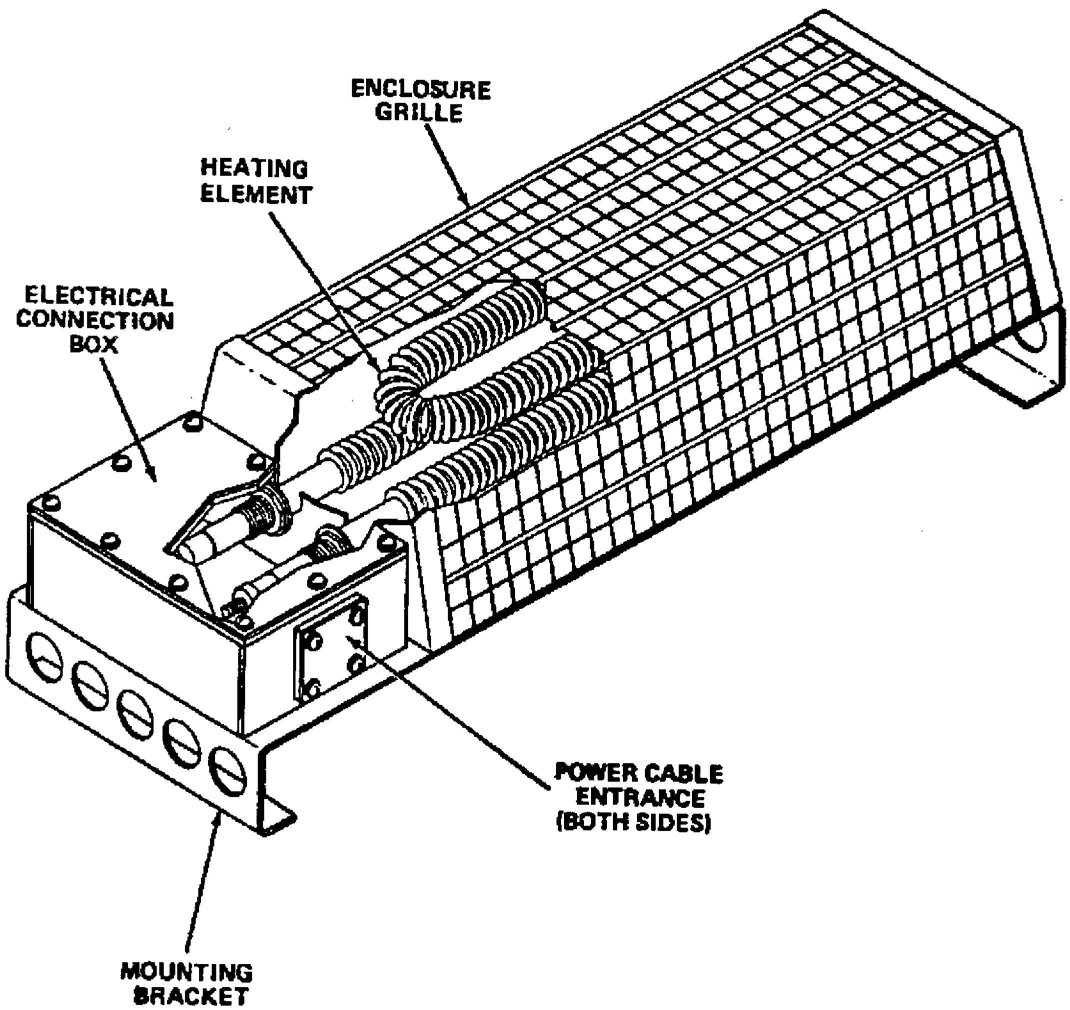


Figure 510-3-5 Turret Heater Type T (Electric)

510-3.2.6 UNIT HEATERS. Navy standard unit heaters (see Figure 510-3-6) are constructed in accordance with military specification MIL-U-17293. Unit heaters are used in large compartments where the amount of heat supplied by the ventilation system is not sufficient to offset heat loss from the space, or in spaces where there is no ventilation supply and the heating requirements exceed the capacity of convection heaters. Unit heaters are typically used in open hangar bays, cargo handling areas and some machinery spaces. The unit heaters consist of a fan and motor, steam heater, thermostatic control valve, steam strainer, drain, fan guard, and louvers. The louvers are located on the discharge side of the heater and are adjustable to allow for directional control of airflow. To keep the fan motor from overheating, the louvers allow no more than 65 percent of the face opening to be closed off. The unit heater is designed for overhead mounting.

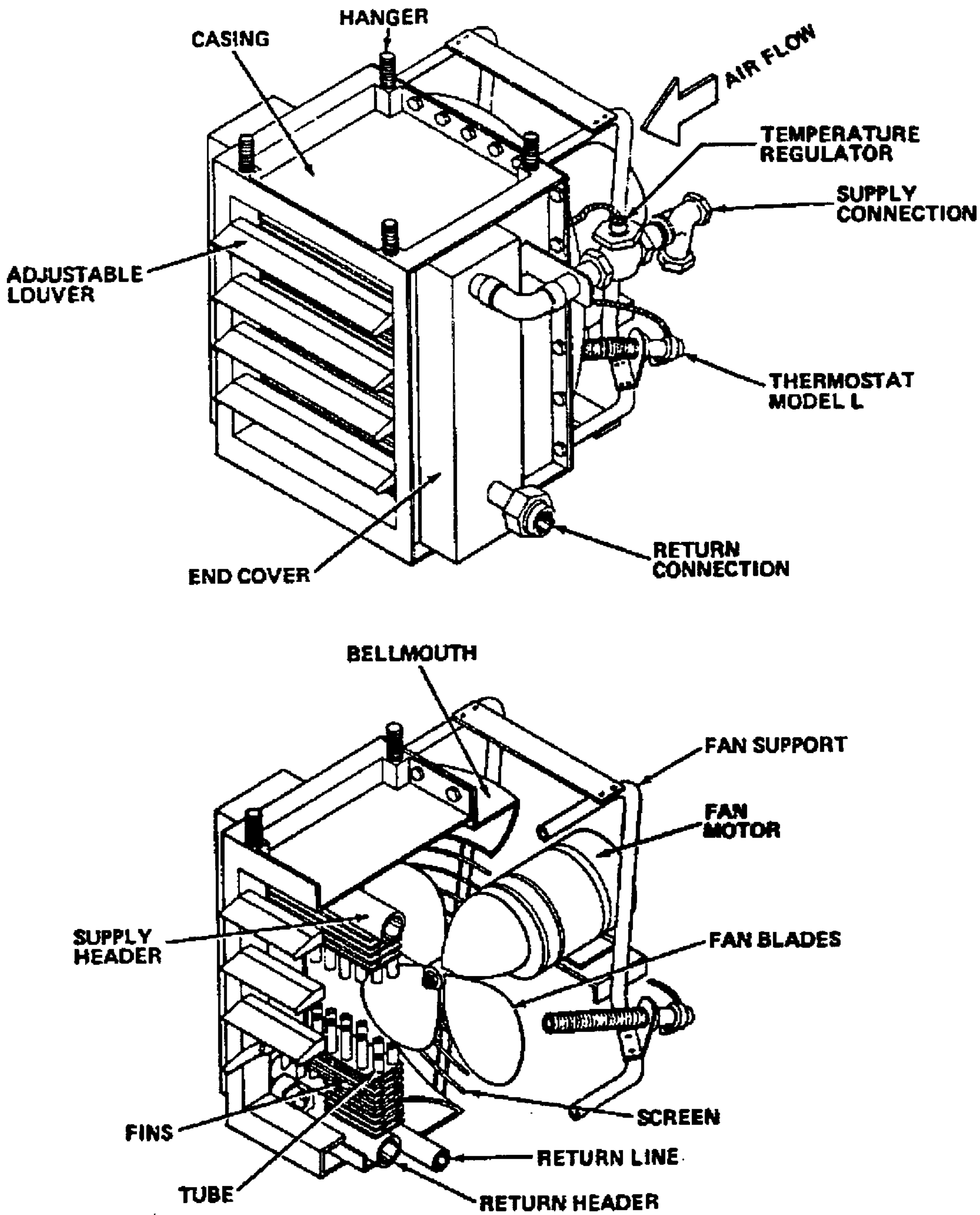


Figure 510-3-6 Unit Heater (Steam)

510-3.3 CONTROL SYSTEM

510-3.3.1 THERMOSTATS. The temperature settings for thermostats are specified in the Ship Information Book and on the heater list drawing. If heating is reported to be unsatisfactory and the heater coil is clean, the operation of the steam valve (if applicable) and thermostat should be checked.

510-3.3.2 STEAM PREHEATER CONTROL. Each steam preheater is controlled by two regulating valves (MIL-V-3155), either in a single valve body or in separate bodies. One of these valves, having a capacity of 25 percent of the heater capacity, is operated by a nonadjustable type W thermostat. This thermostat is located in the outside air or in the duct on the weather inlet side of the heater and is set at the factory to open the valve at 1.7°C (35°F). The other valve, having a capacity of 75 percent of the heater capacity, is operated by an adjustable L-type duct thermostat. This thermostat is located in the duct on the discharge side of the heater and is set at the temperature specified on the HVAC heater list found in the Ship Information Book. In cases where a single steam reheater is used as a combination preheater and reheater, the steam valve is operated by an adjustable room type R thermostat set to maintain the desired room temperature.

510-3.3.3 ELECTRIC PREHEATER CONTROL. Electric preheaters are usually controlled by an enforced zero-firing thyristor power controller with a duct mounted temperature sensor. The controller is a solid state electronic device in a waterproof housing. The controller sends power to the heater when the temperature at the sensor is below the controller's low temperature setpoint. Some ships use solid state controllers without thyristors for electric preheater control. These controllers use a remote contactor (relay panel) to send power to the electric heater. The controller signals the relay panel to send power to the heater when the temperature at the sensor is below the low temperature setpoint. The electric heater is wired so that the fan must be operating before the heater will operate. Electric preheaters are used on ships that do not have steam heating systems, and where steam preheaters are not practical. The Ship Information Book references the actual preheating control equipment in use on a particular ship.

510-3.3.4 STEAM REHEATER THERMOSTATS. For a steam reheater, temperature regulation is accomplished with a type R or 2PD thermostat. The thermostat controls the steam control valve for the heater. The thermostat shall be set at the temperature specified by the HVAC System Diagram in the Ship Information Book. A complete description of the control system including thermostats for steam heaters is contained in NAVSEA 0338-LP-000-7000, **Navy Standard Temperature Regulator for Use With Ventilation Heaters and Unit Heaters.**

510-3.3.5 ELECTRIC REHEATER THERMOSTATS. Electric reheaters are controlled by adjustable two-position, dual-control (2PD) thermostats or by enforced zero-voltage firing, thyristor power controllers. The electric heater is wired so that the fan must be operating before the heater will operate. The thyristor power controller is used with a thermostat that has an adjustable, bulkhead-mounted thermocouple sensing probe. The thermostat should be set as specified by the HVAC System Diagram in the Ship Information Book. For more information on 2PD thermostats, see NAVSEA 0338-LP-035-6000, **Two-Position-Dual Control System for Air Conditioning.**

510-3.3.6 THERMOSTAT GUARDS. Guards or other provisions to prevent tampering by unauthorized personnel should not be used on thermostats. The presence of guards around thermostats increases the lag time (lag time is a measure of the time required for the thermostat to respond to a temperature change), and they are not effective in preventing tampering.

510-3.3.7 WINTERIZING. Heating systems in Naval ships are generally designed to maintain a minimum of 18.3°C (65°F) in quarters, and 21.1°C (75°F) in WR/WC's, at winter design temperature. When ships with heating systems designed for standard winter operating conditions (-12.2°C (10° F)) are detailed for special service in Arctic waters and the heating systems are not known to be adequate, special provisions should be made to augment the heating on an individual ship basis. NAVSEA will direct appropriate modifications if a ship designed for standard winter conditions is detailed for Arctic waters.

510-3.3.8 SUB-ZERO DESIGN. Ships designed especially for operation below the standard design temperature have special heating provisions and special instructions for their operation, with preheaters to handle supply air down to -28.9°C (-20°F) or below.

510-3.3.9 PREHEATER FREEZING. The location of steam preheaters makes them especially vulnerable to freezing. If a preheater becomes inoperative, a progressive freezing of other systems as well as the heating system can occur. Thus it becomes imperative that the temperature regulating valves function properly and that the condensate drains remain open and unplugged. Inspections of preheaters and associated equipment should be conducted both prior to encountering freezing conditions and periodically while experiencing them.

510-3.3.10 LOW HUMIDITY CONDITIONS. Personnel onboard ships operating in cold waters sometimes have complaints of low relative humidity in the ship (20 to 25 percent), resulting in dry nose and throat conditions. This is not considered hazardous. Humidification equipment is not normally provided onboard U.S. Navy ships. The amount of moisture that can be added to the air is a function of the temperature of the ship's shell. Any moisture added to the air of a space in an attempt to raise the relative humidity may immediately condense on cold surfaces. This adds to the condensation problem, and does not increase the relative humidity of the space air at all.

SECTION 4.

AIR CONDITIONING SYSTEMS

510-4.1 INTRODUCTION

510-4.1.1 PURPOSE OF AIR CONDITIONING. The design criteria, in general, for providing air conditioning of spaces aboard ship is to maintain temperatures of 26.7°C (80° F). The basis for this design criteria is OPNAVINST 9640.1, **Shipboard Habitability Program.** Berthing areas are designed to permit a man to sleep without perspiring. Offices and control spaces provide an environment where men can work for an extended period of time without a loss in efficiency. The ship is designed to maintain the designed space temperatures in the summer with weather air conditions of 31.1°C (88°F) DB, 27.0°C (80.5°F) & WB, and 29.4°C (85°F) seawater.

NOTE

The dry bulb temperature of the supply air is assumed to be 32.2°C (90°F) to account for a nominal 1.1°C (2°F) rise due to fan motor heat.

In many cases air conditioning is necessary to cool electrical or electronic equipment. Additionally, some ammunition magazines and stowage areas must be air conditioned to prevent munition deterioration.

510-4.1.2 VARYING WEATHER CONDITIONS. There may be periods in some locations where weather temperature and humidity conditions are higher than the design conditions. If this situation occurs, the air-conditioning system may not be capable of keeping air conditioned spaces at the space design temperature.

510-4.1.3 TYPES OF SYSTEMS. Most air-conditioning systems are recirculation systems. The recirculation system removes air from a space or group of spaces. This air is then passed through a duct cooling coil, where heat from the air is transferred to the chilled water passing through the coil, a fan, and the recirculation ductwork, and then discharged back into the space(s) through duct terminal(s). Navy standard air filters are installed in front of the cooling coil to prevent the rapid fouling of the finned elements. A fan produces the airflow through the system. Many recirculation systems contain heaters for use in the heating season (see Section 3 for information on heating). Other types of air-conditioning systems include gravity cooling coils and duct cooling coils on supply systems. Gravity coils are used in magazines where electrical equipment may be hazardous. Duct cooling coils are used in some supply systems to cool and remove moisture from supply air.

510-4.1.4 REPLENISHMENT AIR. Weather air is supplied to air-conditioning systems. This air is called replenishment air. The replenishment air is usually provided by a branch of a ventilation supply system. The weather air provides fresh air to air-conditioning recirculation systems to remove odors, replenish oxygen, and prevent carbon dioxide build-up. The weather air also replaces stale air being removed by the ventilation exhaust system.

510-4.1.5 HEAT GAIN. The heat added to the air in the space is called the heat gain and comes from several sources. The following heat gain information is intended for ship's force use.

510-4.1.6 HEAT GAIN FROM PERSONNEL. Heat is generated within the human body by oxidation of food.The rate at which food is converted, or metabolized, is commonly called metabolic rate. The metabolic rate varies with the individual and with his activity level. The normal body processes are performed most efficiently at a deep body tissue temperature of about 37.0°C (98.6°F); this temperature may vary only through a narrow range in healthy people. However, the human body can maintain this temperature, through a wide ambient temperature range, by conserving or dissipating the heat it generates. This heat is carried to the surface of the body by the blood stream and is dissipated to the air by:

a. Radiation from the body surface to the surrounding surfaces (sensible heat)

b. Convection from the body surface and the respiratory tract to the surrounding air (sensible heat)

c. Evaporation of moisture from the body surface and in the respiratory tract to the surrounding air (latent heat)

The amount of heat dissipated by radiation and convection is determined by the difference in temperature between the body surface and its surroundings. The body surface temperature is regulated by the quantity of blood being pumped to the surface; the more blood, the higher the surface temperature up to a limit of about 35.6°C (96°F). The heat dissipated by evaporation is determined by the difference in vapor pressure between the body and the air. The total personnel heat gain varies with the type of work (body activity) being performed (a sleeping person will produce less heat gain than a person performing physical labor). The total personnel heat gain does not vary with the ambient temperature. However, it is important to note that a change in the temperature results in a change in the ratio of latent-to-sensible heat from personnel. Thus when the temperature within the space is high, there will be a low addition of sensible heat and a high addition of latent heat from personnel.

510-4.1.7 HEAT GAIN FROM EQUIPMENT. The sensible heat gain from operating electronic equipment is the same regardless of the space temperature. The sensible heat gain from other equipment, such as pumps, boilers, piping, or valves, varies with the space temperature. As the temperature in the space increases, the heat gain decreases. The latent load from equipment will, however, remain approximately constant since it is primarily due to steam and water leakage. If any open water surface exists within the space, an amount of latent heat is added which is dependent upon the temperature of the water and the dry bulb and wet bulb temperature of the air in the spaces. This latent heat gain increases as the temperature of the space rises.

510-4.1.8 BOUNDARY HEAT GAIN. Sensible heat is transmitted through the boundaries of the space to or from the surrounding areas. This heat transfer is dependent upon the temperature differential and insulation between the space in question and the surrounding spaces. The temperature of a space being air conditioned is usually lower than that of surrounding spaces that are not air conditioned. In this case the heat flow is into the space being cooled and added to the net heat gain. If the space temperature is above that of the surrounding spaces, heat will flow outwards and is subtracted from the total heat load. This heat transfer is called a ″heat loss.″ If the space temperature is the same as the surrounding spaces there will be no heat transfer through the bulkheads.

510-4.1.9 OTHER SOURCES. Additional sources that can increase the heat gain are heat added by replenishment air and solar energy. Replenishment air will add to the heat gain if the air supplied to the air-conditioning system is at a higher temperature than the space(s) the recirculation system serves. Solar heat is the radiant energy that is absorbed by the bulkheads and decks of spaces with weather exposure. The solar heat increases the temperature of exposed bulkheads and decks, and thus increases heat transfer from the weather.

510-4.1.10 HEAT BALANCE. After an air-conditioning system has operated within a space for a period of time, the temperature within the space will level off or reach equilibrium. When the temperature levels off, there will be an exact balance between the heat added to the space and the heat removed by the cooling coils.

510-4.1.11 EQUILIBRIUM CONDITIONS. When the cooling equipment is properly designed for the heat gains, the equilibrium dry bulb and wet bulb temperatures finally reached will be the design condition. If the capacity of the cooling equipment is too low, the amount of sensible heat removed will be insufficient and the space temperature will be higher than the design temperature. The increase in space temperature will reduce the sensible heat added to the space but will increase the latent heat added to the space by personnel. When equilibrium conditions are reached within a space, the latent heat added to the space is equal to the latent heat removed from the space.

510-4.1.12 RELATIVE HUMIDITY. Air leaving the cooling system is at a very high relative humidity, but because of its low temperature, the actual moisture quantity in the air is low. If enough water vapor is removed from the warm air as it passes through the cooling coil, a constant relative humidity will be maintained in the space. However, if the quantity of moisture being added to the air in a space exceeds that being removed, the relative humidity of the space will increase until a condition of equilibrium is reached.

510-4.1.13 SENSIBLE HEAT GAIN. Sensible heat gain should be kept to a minimum to reduce the load on the air-conditioning system. The use of unnecessary electrical equipment should be avoided.

510-4.1.14 LATENT HEAT GAIN. The latent heat gain should be kept to a minimum. If any open water surfaces exist within a space, the water should be removed or covered where possible or the area of water surface kept to a minimum. Steam leaks should be repaired. This will reduce the amount of moisture added to the air and reduce the air cooling required for a space.

510-4.2 AIR-CONDITIONING EQUIPMENT

510-4.2.1 GENERAL. Air-conditioning equipment used by the U.S. Navy uses refrigeration machinery to chill water that is used as a refrigerant for cooling coils. The refrigeration machinery includes a pump that supplies chilled water to the chilled water piping. The chilled water is cooled to a temperature of 7.2°C (45°F) in a water chiller located within the refrigeration machinery. Pumps circulate water through the chilled water piping and cooling coils. The water picks up heat from the space and returns to the chiller for recooling. In this type of system the water leaving the chiller is kept at a constant temperature by the refrigeration machinery controls. A description of the principles of operation, a general description of the equipment, and instructions for the refrigerant plant operation and maintenance are given in **NSTM Chapter 516, Refrigeration Systems.** In addition, a technical manual covering the specific unit supplied is furnished for each installation. The details of operation, troubleshooting, and maintenance of the equipment should be in accordance with **NSTM Chapter 516** and with the appropriate technical manuals. Chilled water system characteristics, operation, maintenance, and services are described in Appendix A, Chilled Water Systems.

510-4.2.2 NAVY STANDARD AIR CONDITIONING EQUIPMENT. Duct cooling coils, gravity coils, unit coolers, fan-coil assemblies, and some fan-coil units used for air conditioning are Navy standard. The cooling medium for Navy standard duct cooling coils, unit coolers, fan-coil assemblies, gravity coils, and fan-coil units is chilled water.

510-4.2.2.1 Navy Standard Duct Cooling Coils. There are two series of cooling coils presently installed onboard Navy ships, the older ″50 series″ and the currently used ″60 series.″ They are interchangeable as to duct size, net face areas, and performance. There are some differences in duct flange connections and overall dimensions. The 50 series cooling coil has a removable insulated drain pan for collecting condensate and directing it to a drain line. A label plate indicating direction of airflow is permanently secured to the drain pan. The drain pan must be attached so that the arrow is in the same direction as the airflow. The direction of the airflow may be determined by removing the access plate or cover in the duct connected to the coil and feeling the airflow with a hand. Caution - Do not insert fingers or hand into the fan when feeling the airflow direction. For effective cooling, all air cooling coils must be piped for counter flow (i.e., chilled water into header on leaving-air side of coil. A 50 series cooling coil) is shown in Figure 510-4-1.

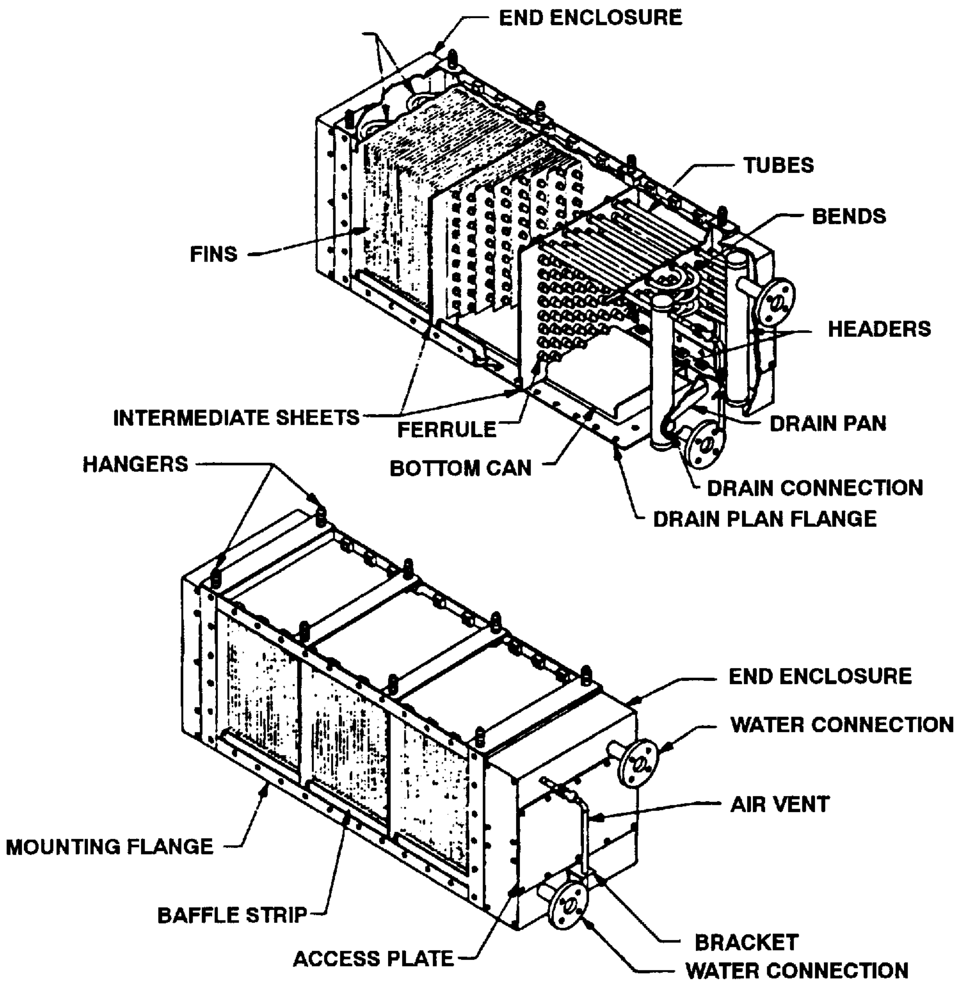


Figure 510-4-1 Series 50DW Cooling Coil

510-4.2.2.2 Navy Standard Fan-Coil Assembly. The fan-coil assembly (manufactured to meet MIL-A-23798) consists of a fan and motor, a chilled water cooling coil, electrostatic precipitator (Type I only), air filters, internal bypass air damper, thermal insulation, and noise attenuation material housed in a two- or three-section unit. Supply and return ducts are connected to the upper portion of the assembly. The cabinet is designed to permit ready connection to a power source, a drainage line, and chilled water supply and return lines. The fan-coil assembly draws air downward from the inlet, through the air filters, and across the electrostatic precipitator (Type I only). The air is then ducted through the fan-motor section into and through the chilled water cooling coil, upward through the fan and motor section, and discharged to the supply outlet. See Figure 510-4-2 and Figure 510-4-3 for illustrations of fan-coil assemblies. The three types of fan-coil assemblies are as follows:

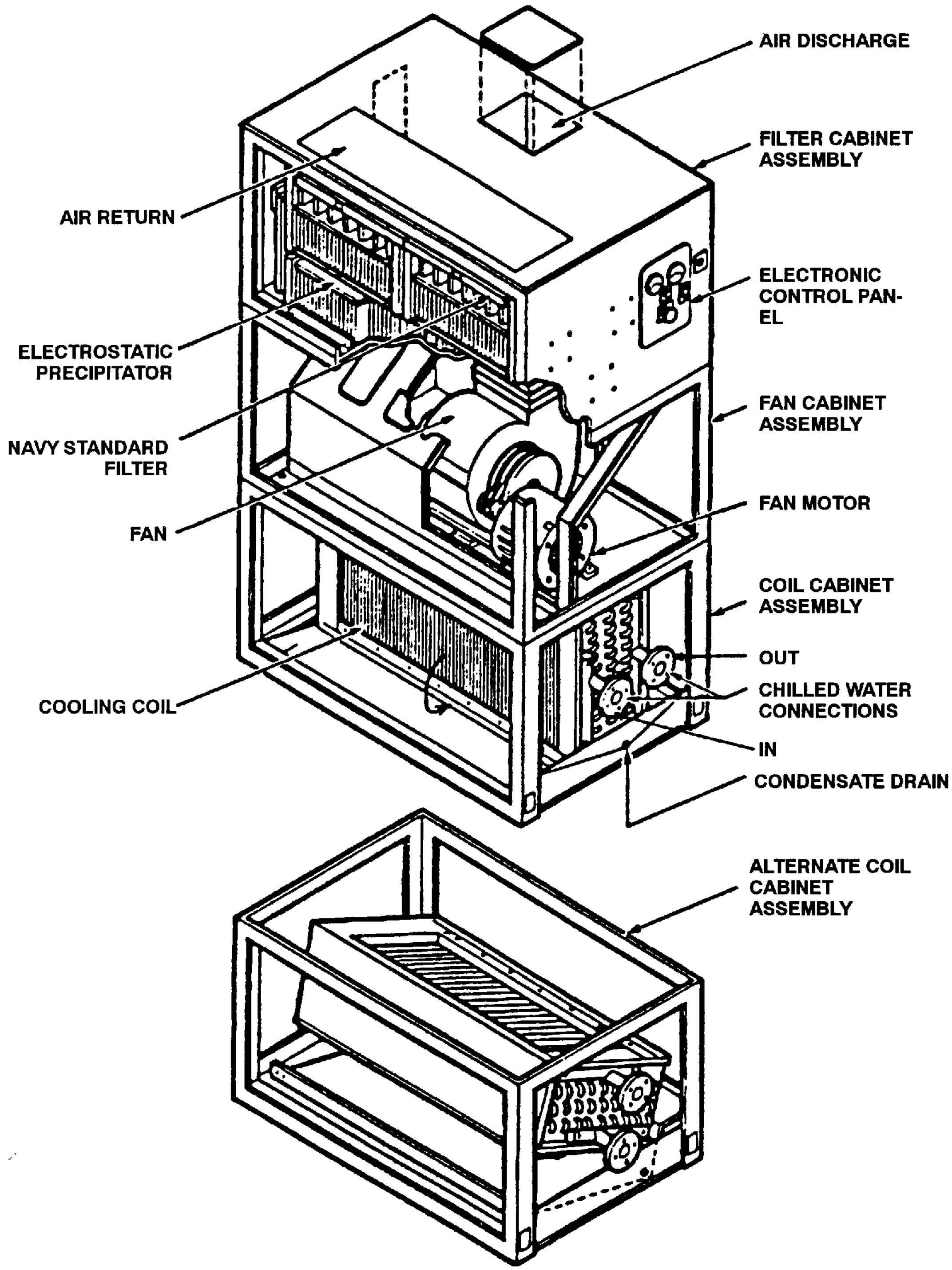


Figure 510-4-2 Fan-Coil Assembly - Type I

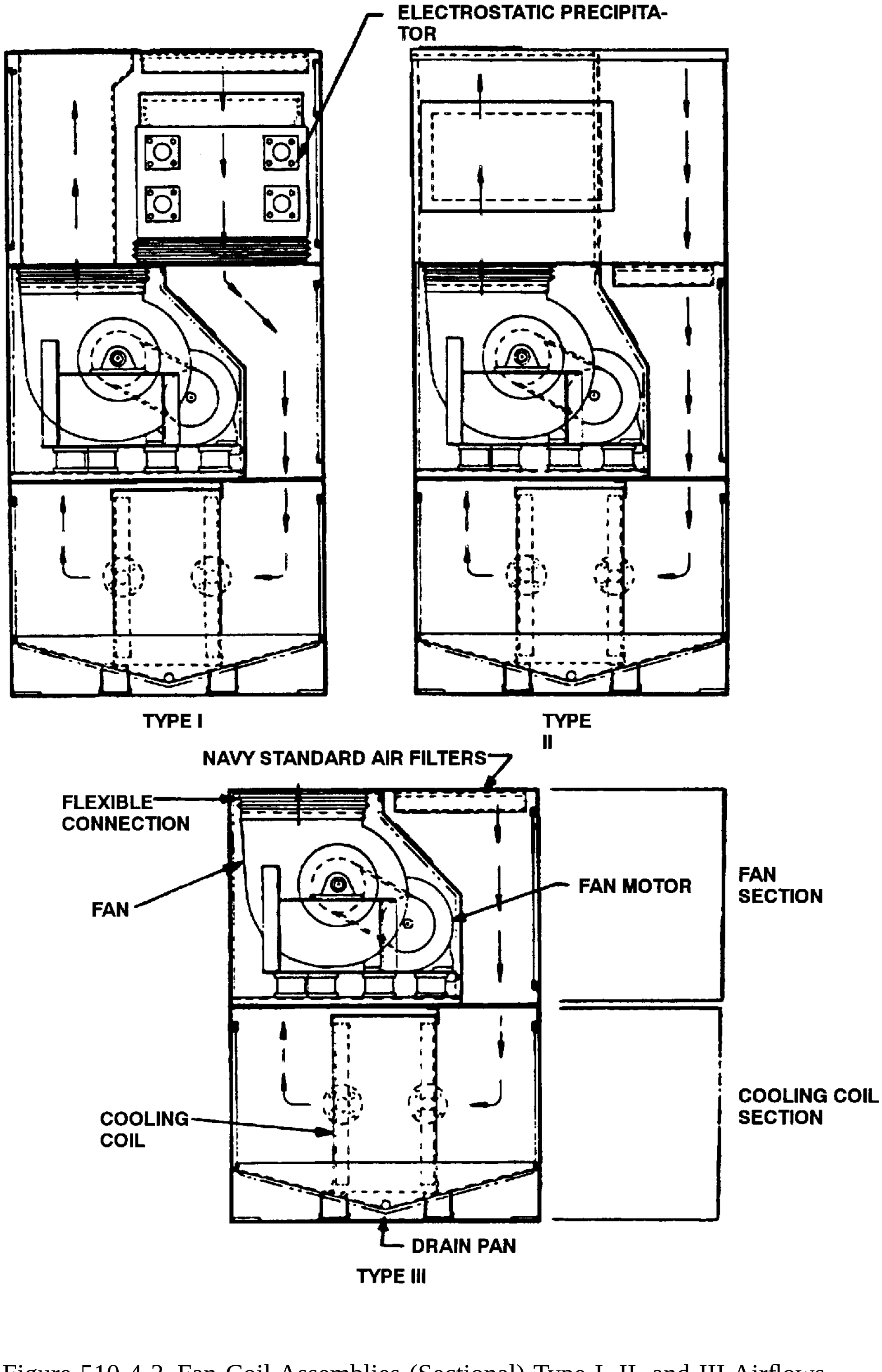


Figure 510-4-3 Fan-Coil Assemblies (Sectional) Type I, II, and III Airflows

Type I - Three-section unit consisting of a cooling coil section a fan-motor section and an electrostatic precipitator section with power pack and air filters.

Type II - Three-section unit consisting of a cooling coil section, a fan-motor section, and an air distribution plenum section with air filters.

Type III - Two-section unit consisting of a cooling coil section and a fan-motor section with air filters. Units built before 1973 were constructed in one piece.

510-4.2.2.3 Fan-Coil Units. Fan-coil units are designed for horizontal mounting in the overhead, or vertical mounting on bulkheads. The fan-coil unit consists of a fan and motor, motor controller, air filters, inlet and outlet grills, thermal and acoustic insulation, a chilled water cooling coil, and may contain an electric heater. Some fan-coil units also contain a thermostat. Ductwork may be connected to inlet and outlet openings on some units. The fan-coil unit cabinet is designed to permit ready connection of a power supply, chilled water supply and return lines, and a drainage line. The fan-coil unit draws air through the inlet and the air filters, through the fan, into and through the cooling coil, through the heater (if installed), and discharges the air through the supply outlet. A fan-coil unit is shown in Figure 510-4-4.

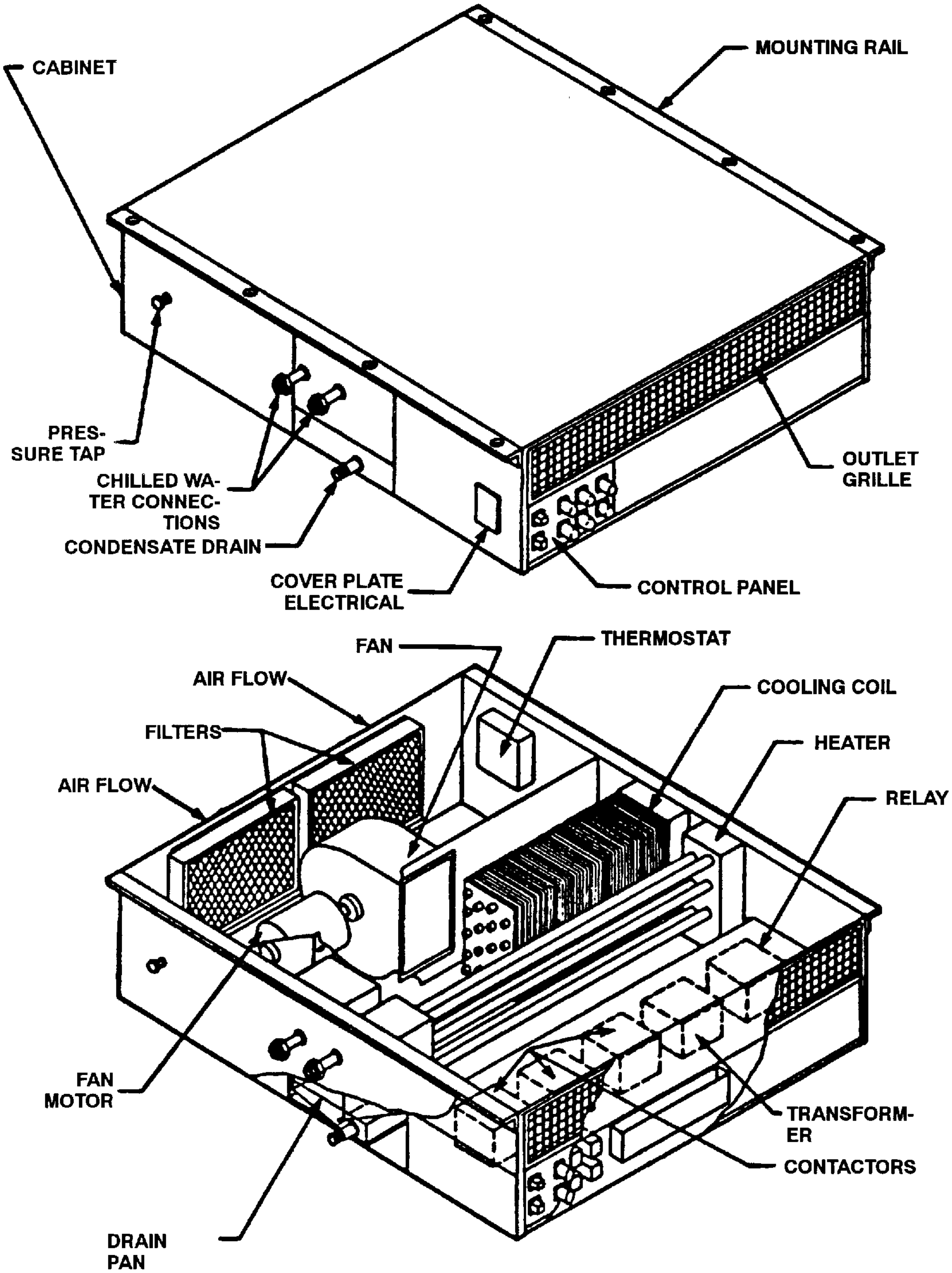


Figure 510-4-4 Fan-Coil Unit - Type H

510-4.2.2.4 Gravity Cooling Coils. Gravity cooling coils (shown in Figure 510-4-5) are used primarily in spaces where the load is small, and where electrical equipment (which could spark) would constitute a hazard, such as magazines where air conditioning is required. The gravity cooling coil is of the extended surface type consisting of copper tubing expanded into copper fins. It is designed for overhead mounting and uses chilled water as the cooling medium (refrigerant). It is suspended at least 4 inches below the insulated overhead because it depends on convection currents to remove heat from the space. The gravity cooling coil has a removable drain trough with drain connections on both ends of the trough. The coil must be mounted with drains athwartship so that the chance of condensate overflow in rough weather is reduced. Drain connections should be made to both sides of the drain trough and brought together to discharge condensate from the coil to a receptacle or deck drain. Where the condensate from the coil is drained into a receptacle, the drain should extend into the receptacle through a cover in order to prevent re-evaporation of some of the condensate. If the cover is airtight, a small hole should be provided in the cover to vent air as the receptacle fills.

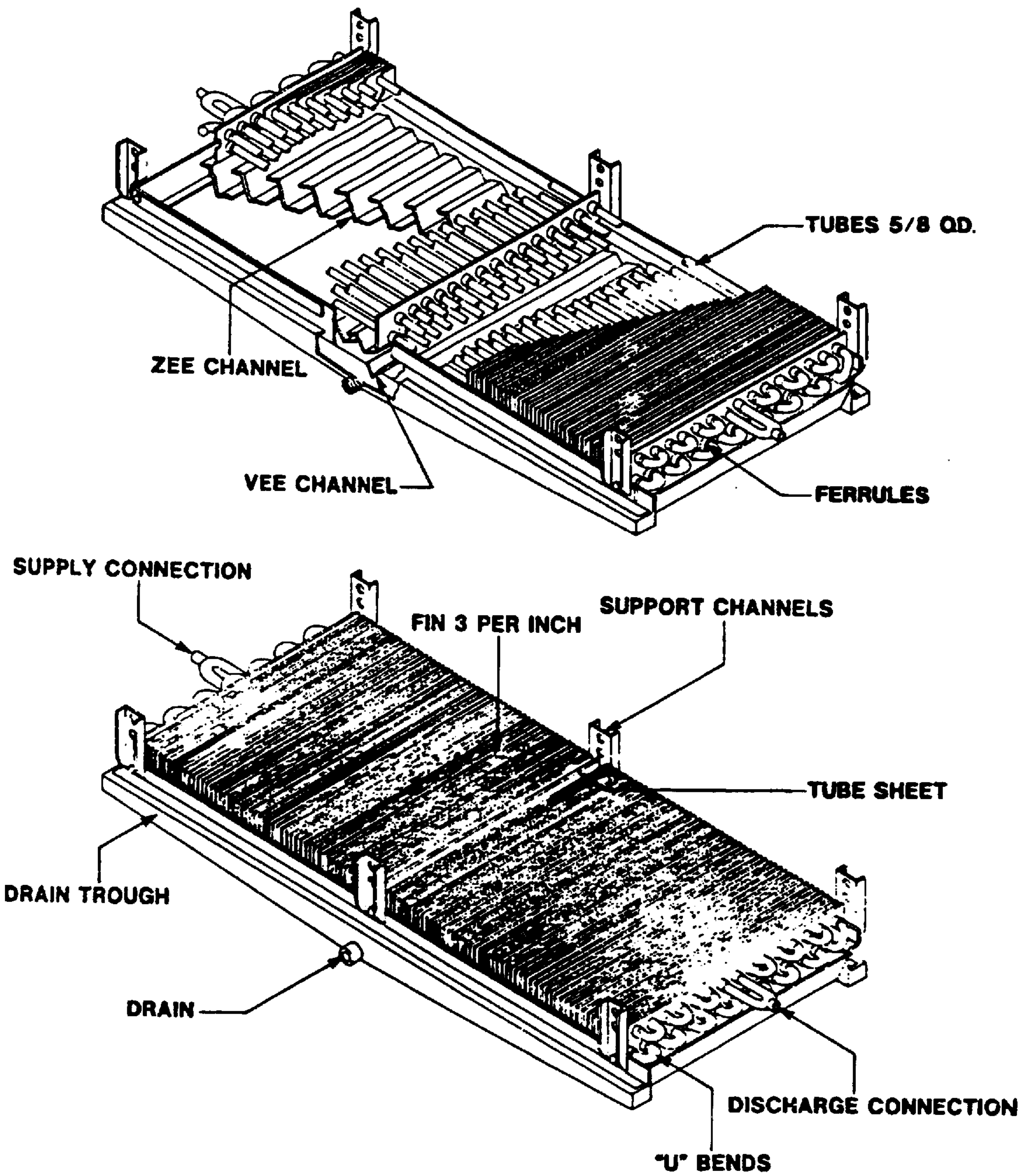


Figure 510-4-5 Gravity Coil

510-4.2.2.5 Unit Coolers. Navy standard unit coolers are used primarily in isolated, air-conditioned compartments where it is impractical to install a recirculating system. Unit coolers consist of a standard DW cooling coil, a fan assembly, and a suitable transition. Navy standard filters are installed in the transition between the fan and the cooling coil. Control of the chilled water is described in paragraph 510-4.4.2. Unit cooler motors operate from the ship's lighting circuit. The unit cooler is not suitable for use with the distribution ductwork. Therefore, the use of unit coolers is limited to small compartments or where air distribution is not a prime factor. They also may be used to augment an existing recirculating system. An illustration of a unit cooler is shown in Figure 510-4-6.

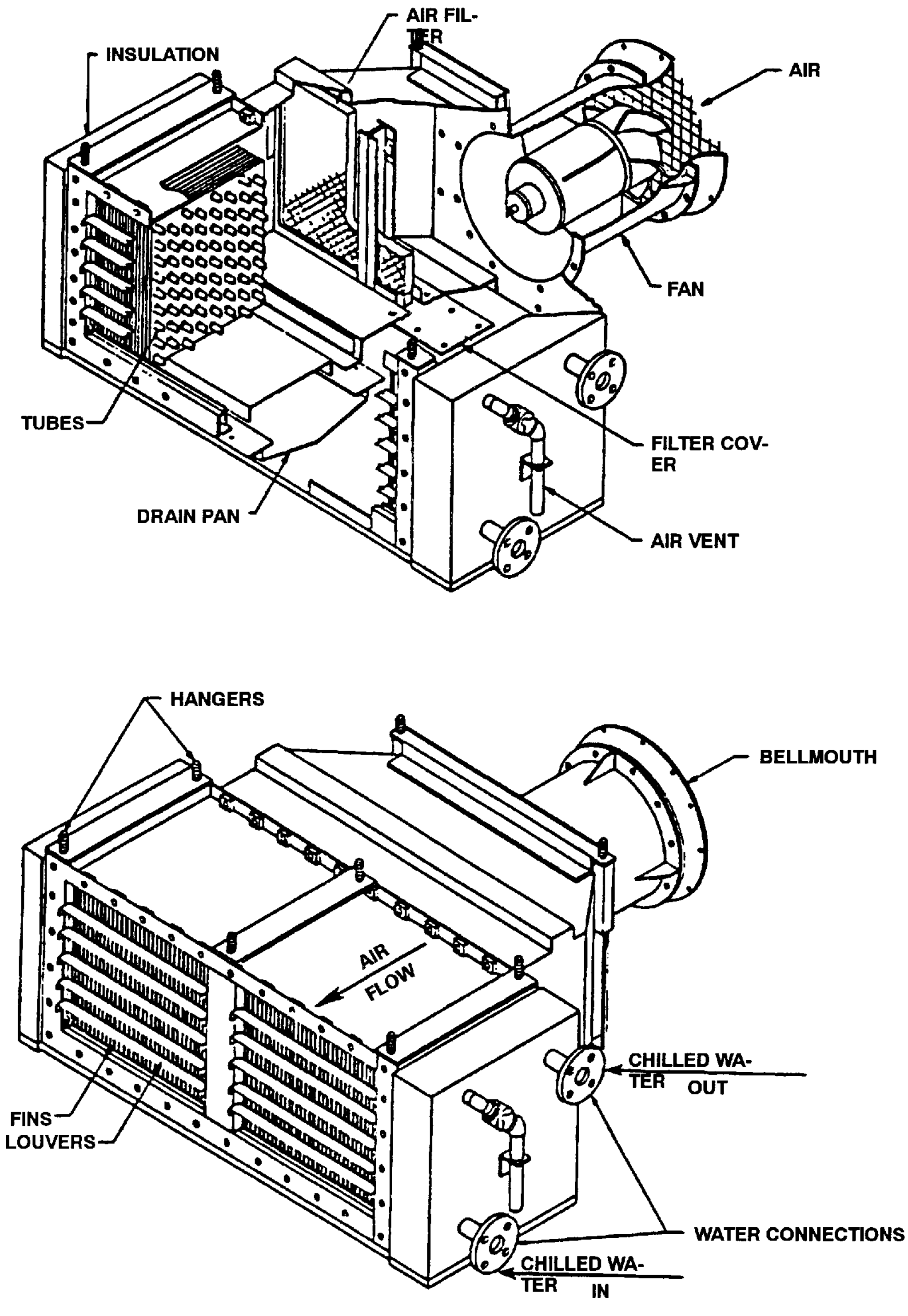


Figure 510-4-6 Series 50UW Unit Cooler

510-4.3 OPERATION

510-4.3.1 GENERAL. Means for providing replenishment (fresh) air are incorporated in air-condition ing installations. Most installations have a ventilation supply air terminal that provides fresh air to the recirculation system. The air supply is replenished in order to remove odors, replenish oxygen, and dilute carbon dioxide. Air-conditioning systems are generally recirculating systems with a fixed amount of replenishment air. Recirculating systems are generally of little value for removal of stale air, toxic vapors, or replacement of depleted oxygen levels from a space. Air from the space is passed through the cooling coil (where heat from the air is transferred to the chilled water passing through the coil) and the distributing duct system, and then discharged back into the space through duct terminal(s). Navy standard air filters are installed in front of the cooling coils to prevent the rapid fouling of the finned elements. Navy standard fans, or the internal fan in fan-coil units and fan-coil assemblies, produce the airflow through the system. When a two-speed fan is used on an air-conditioning system, it should be wired for high speed operation only. If both speeds are connected, the fan should be operated at high speed only. The fan is usually downstream of the cooling coil but some may be located upstream. Recirculation systems serving vital spaces are, to the extent possible, designed so that a particular system serves only a single vital space or a single group of related vital spaces.

510-4.3.2 DISTRIBUTION OF LOAD. When an air-conditioning recirculating system is employed to cool several separate spaces, satisfactory conditions will be maintained in these spaces only when the ratio of latent-to-sensible heat load is similar for all spaces, and the distribution of cooling effect is in proportion to the load in the respective spaces. If the latent-to-sensible ratio in these spaces is different, a high wet bulb temperature may result. This type of problem cannot be solved by thermostat adjustment. If this situation occurs, it should be reported to NAVSEA by using the Ventilation Alteration Request (see Section 8).

510-4.3.3 CHILLED WATER SYSTEMS. Ship chilled water systems and their operation are fully described in Appendix A, Chilled Water Systems. In chilled water systems it is necessary that the correct amount of water be delivered to each coil. The water flow for each cooling coil is indicated on the cooling coil list referenced in the Ship Information Book. If this flow is restricted to less than the coil requirement, it tends to raise the average coolant temperature in the coil, thus reducing the sensible heat and latent heat removed by the coil. If too much water flows through the coil, it will usually cause only a slight increase in coil capacity, but it increases the amount of water the pump must handle. The pump is selected based upon the flow necessary in the chilled water system. Changing the water flow to any coil in the system may unbalance the system, depriving some coils of their required flow. A fixed-flow fitting or a venturi meter and water regulation valve are provided at each cooling coil to regulate the flow of water. In systems with fixed-flow fittings, rebalancing should not be necessary. Should a system become unbalanced where venturi and water regulation valves (throttling valves) are installed, the following steps shall be taken to rebalance the system:

1. Set all thermostats at 10°C (50°F) or lower to ensure that water flows to all coils during balancing.
2. Starting with the coil that has the longest piping run from the pump, adjust the throttling valve to allow the flow designated for this coil. This is done by connecting a portable differential gage across the taps of the venturi meter and consulting the calibration curve for that size venturi meter.
3. Move to the cooling coil that has the next longest piping run, adjust to its proper flow, and move on down the system until all cooling coils in the system are adjusted.
4. Return to the first cooling coil that was adjusted and make a second reading. If the flow has not changed appreciably, the water distribution system can be assumed to be properly balanced. If the first coil flow has changed as much as 10 to 15 percent, the operation should be repeated.

5. When the coil next to the pump is readjusted, return a third time to the first coil. The water flow on this third check of the furthest coil should now be very close to the required flow for that coil.

6. After the required water flow is reached, set all the thermostats as shown on the applicable HVAC system diagram in the Ship Information Book.

510-4.3.4 MAGAZINE AIR CONDITIONING. In magazines that are air conditioned, Navy standard gravity type cooling coils are usually used. Gravity coils do not use a fan for air circulation. These coils depend on convection currents to remove heat from the air in the magazine space. A two-position thermostatic switch (on-off) controls the gravity type cooling coil. The thermostat bulb extends into the space through a threaded fitting welded to the bulkhead. The switch mechanism and magnetic valve are located outside the magazine. There is a definite space condition (temperature and relative humidity) that will be obtained when equilibrium conditions between space heat load and coil capacity are reached. With the average magazine air-conditioning system, equilibrium will be reached in about one hour after the space is secured. Condensate from the gravity coils is sometimes piped to receptacles on the deck of the magazine. These condensate receptacles must be emptied at regular intervals to prevent overflow. See paragraph 510-4.2.2.4 for additional information.

510-4.3.5 MAGAZINE CONDENSATION. Operation of blowout ventilation can cause condensation within the space when the relative humidity of the air supplied to the ammunition magazine is high. Use of this system in magazines provided with gravity cooling for other than blowout purposes will nullify the cooling effect of the cooling coils described in paragraph 510-4.3.4. Ensure that all blowout ventilation is operated in accordance with the DC classification of the ventilation system closures.

510-4.3.6 GALLEY AND PANTRY AIR CONDITIONING. The air conditioning of galleys and pantries poses special problems in odor control. Electrostatic precipitators (ESP), if installed, are upstream of the cooling coils. The ESP is designed to remove and collect particulates (aerosols) that are less than 10 microns in diameter, such as smoke and oil mist, from the air passing through the precipitator. In order to reduce maintenance on the ESP, a prefilter is located upstream to remove large particles. The air-conditioning systems of galley and pantry spaces must be cleaned frequently as specified by the PMS card to minimize odor problems. The Gaylord Ventilator extracts most of the grease, dust, and lint particles from the airstream passing through it without the use of filters, revolving devices, removable parts or running water. This device reduces the fire hazard and maintenance problems normally caused by the accumulation of these contaminants in the ductwork. The hot, contaminant-laden air rising from the cooking surface moves through the ventilator at a high speed and is forced to make a series of turns around the baffles. As the high velocity air turns around each baffle, the heavier-than-air particles of grease, dust, and lint are thrown out of the airstream by centrifugal force. The extracted grease, dust, and lint are collected in grease gutters within the ventilator, remaining out of the airstream until removed by the cleaning cycle.

510-4.4 AIR-CONDITIONING CONTROLS

510-4.4.1 THERMOSTATIC CONTROL. A thermostat is a device that responds to temperature changes. Thermostats are part of the control system for the HVAC system. When the space heat gain is within the capacity of the air-conditioning equipment serving a space, the control system will maintain an approximately uniform space temperature. When the heat load is beyond the capacity of the cooling equipment, the space temperature will never fall to the setpoint of the thermostat, the cooling system will operate continuously, and no improvement can be effected by thermostat adjustment. When the space heat gain is equal to or greater than the capacity of the cooling equipment, a lower setting of the thermostat will not interfere with the operation of the cooling equipment and will have no effect on the temperature conditions of the spaces. During moderate weather, when the space heat gain is well within the capacity of the cooling equipment, it is possible to maintain a lower temperature in the space by adjusting the thermostat to a lower temperature. In general, thermostats should be set to require cooling when the dry-bulb temperature of the space is above 23.9°C (75°F).

510-4.4.2 THERMOSTATIC CONTROL TYPES. Control of the majority of systems is by the two-position type control (2PD), often called ON and OFF control. A thermostat is a temperature sensitive control switch or switches. The 2PD thermostat has two normally open switches, one for heating, and one for cooling. These switches are arranged so that they cannot close simultaneously. The 115-Vac power to the thermostat may be taken from the fan circuit, or may be taken from a lighting circuit. Power may still go to the thermostat even after the fan is shut off. For cooling, this type of control uses a thermostat to energize the solenoid in a magnetic valve, in order to permit full flow of chilled water through the coil when the space temperature increases beyond the setting of the thermostatic switch. See Figure 510-4-7 for an illustration of a 2PD thermostat. The other common control system uses a type 222-10 thermostat to sense temperature changes. The type 222-10 thermostat consists of a temperature sensing bulb with capillary tubing connected to an electric switching device. The 222-10 thermostat is an ON/OFF control switch. The 222-10 thermostat is used in magazines and other spaces where electrical equipment is not permitted. The temperature-sensing bulb is mounted inside the space, and is connected by capillary tubing to an electric switching device located outside the space. The most common usage of 222-10 thermostats is to control the flow of chilled water to gravity coils in magazines. For more information on thermostats, see NAVSEA 0938-LP-050-1010, **222-10 Thermostats;** and NAVSEA 0338-LP-035-6000, **Two-Position-Dual Control System for Air Conditioning.**

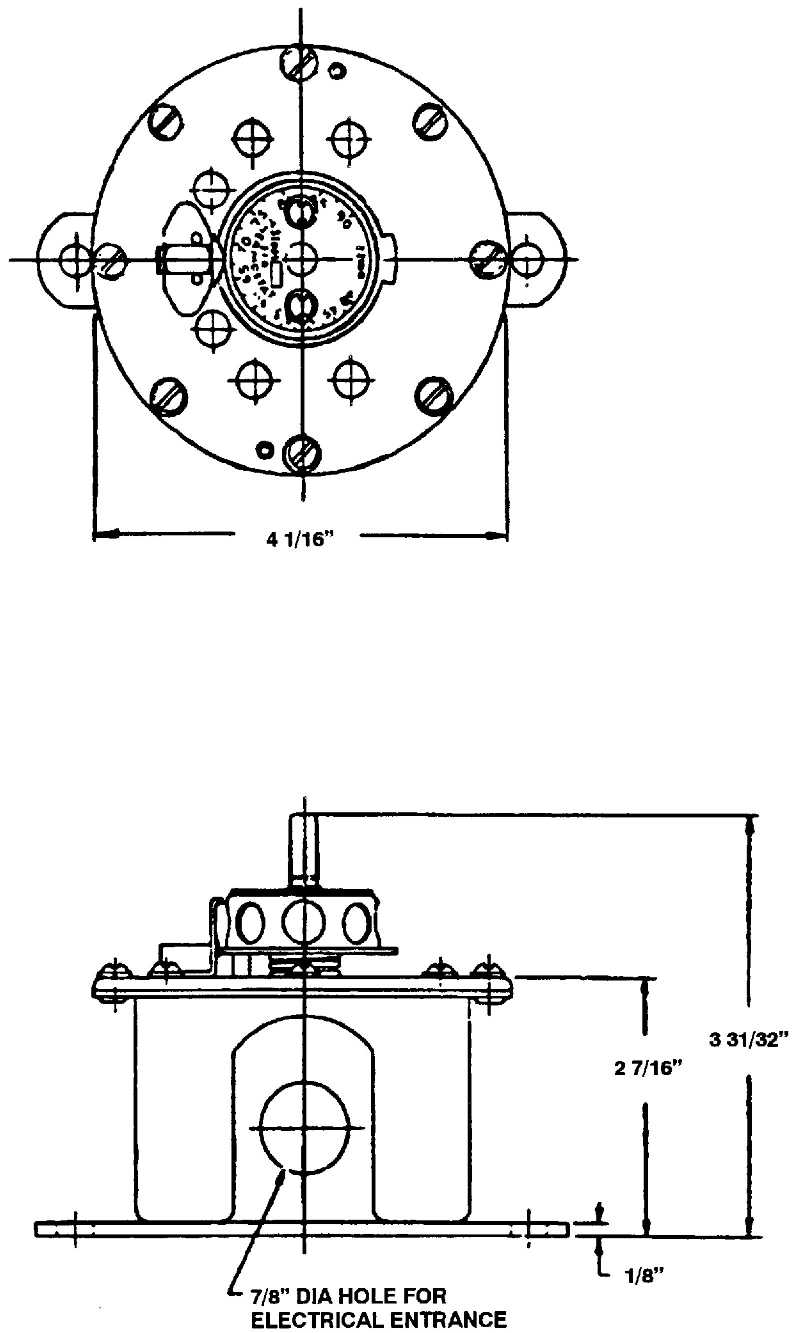


Figure 510-4-7 2PD Thermostat

510-4.4.3 HUMIDITY CONTROL. Relative humidity in most air-conditioned spaces is reduced by the cooling coil serving the space. Moisture in the air is condensed on the fins of the cooling coil as the air passes through the cooling coil and the moisture is then drained away from the coil. Most air-conditioned spaces do not need further control of humidity. Certain areas on some ships require that space relative humidity be controlled. Three types of humidity controls are used: electronic, 2PD, and (occasionally) pneumatic. In humidity control a humidistat and a thermostat switch the cooling coil and reheater on and off. The most common type of humidistat used is the nylon element type. In air-conditioning recirculation systems with humidity control, reheat is employed using a Navy standard duct heater (steam or electric). Under load conditions where the relative humidity is more than the design condition, the heater will be switched on by the humidistat to reduce the air relative humidity by increasing the space temperature. When dry bulb temperature rises above the thermostat setting, the cooling coil is energized, and the air going through the cooling coil is cooled. The cooling coil and reheater may operate simultaneously to control room humidity and temperature. This is virtually an arbitrary increase in space sensible load, which is automatically produced to rebalance the sensible-to-total heat ratio of the load to prevent the space relative humidity from exceeding the required percentage. Installations controlled by a 2PD thermostat and a humidistat have the humidistat connected in parallel with the reheater switch of the thermostat. A drop in space temperature or a rise in relative humidity will energize the reheater. For information on pneumatic and electronic humidity control systems, see the Ship Information Book or specific technical manual for the installation.

510-4.4.4 PRECOOLING COIL TEMPERATURE REGULATION. Precooling coils have the chilled water flow controlled with an ON-OFF control system using a 2PD thermostat or by a modulating control valve with bulb sensor, in accordance with military specification MIL-V-19772 Class 2, type 2. The modulating control valve has a manual override and fails safe in the open position (full flow). The modulating control valve or the 2PD thermostat should be set as specified in the Ship Information Book.

SECTION 5.

COLLECTIVE PROTECTION SYSTEMS

510-5.1 TYPES OF SYSTEMS

510-5.1.1 GENERAL. Collective protection systems (CPS) protect shipboard personnel from chemical, biological or radiological (CBR) contamination. Collective protection systems are either Total Protection systems (TP) or Limited Protection systems (LP). Areas of the ship with total protection systems protect against CBR contamination and are designed to be pressurized to a positive 2 inches water gage (WG) with respect to the weather. Pressure control valves are installed to limit the pressure of a TP pressure zone to 3.0 inches water gage. Each pressure zone within the TP system is served by at least two pressurization supply systems or one pressurization supply system with two fans in parallel. Areas of the ship with limited protection systems protect against biological and radiological contamination and are not positively pressurized. Limited filtering of weather air is accomplished by high efficiency particulate air (HEPA) filters. LP systems are usually limited to normally ventilated (not air conditioned) spaces such as engine rooms or auxiliary machinery spaces.

510-5.1.2 TOTAL PROTECTION SYSTEMS. TP systems employ high pressure vaneaxial supply fans and companion centrifugal exhaust fan(s). The supply system is configured as follows: an antiblast valve located at the weather inlet; a prefilter bank; Navy standard preheater(s); a dirty side air plenum chamber, accessible only from the weather, of sufficient size to allow for ready removal of prefilters and CBR filter elements; a CBR filter bank with filters (the filters are a HEPA filter followed by a charcoal gas filter); a clean side air plenum sized to permit blanking off of CBR filters; a high pressure vaneaxial fan or fans; a closure (wired to close on fan failure and, if applicable, on missile firing); a cooling coil for precooling (if required); and the supply distribution ductwork. The exhaust system is configured as follows: the exhaust system ductwork; centrifugal fan(s); a three-position damper (fully open, fully closed, and 2 inches water gage pressure drop); and watertight ductwork to the weather.

510-5.1.2.1 TP Supply Systems. Each pressurization supply fan is independently connected to the clean side air plenum. The CBR filters for TP systems consist of HEPA and charcoal filters, one filter inside the other, and conform to NSN 4240-01-067-5605. The TP systems filter housings for CBR filters are constructed to NAVSEA Drawing No. 512-6263417. Airflow is radially outward from inside the CBR filter to outside, passing through the HEPA filter first and then through the activated charcoal gas filter. The HEPA filter is the smaller of the two-filter set, and it is located inside the larger gas filter. The paper particulate portion of the CBR filter will remove biological and radiological particulates from air. The particulate filter weighs approximately 8 pounds. Sealing to prevent air bypassing the filter is by two closed-cell neoprene gaskets on each end of the filter. The gas filter portion of the CBR filter is filled with activated charcoal and will remove undesirable gas molecules which will penetrate the particulate filter. The gas filter weighs approximately 35 pounds. Sealing to prevent air bypassing the gas filter is by two closed-cell neoprene gaskets on each end of the gas filter. Each supply fan has an airtight closure downstream of the fan to prevent recirculation through an idled fan and to preclude loss of zone pressure due to fan failure. See Figure 510-5-1 for a TP supply fan room typical arrangement.

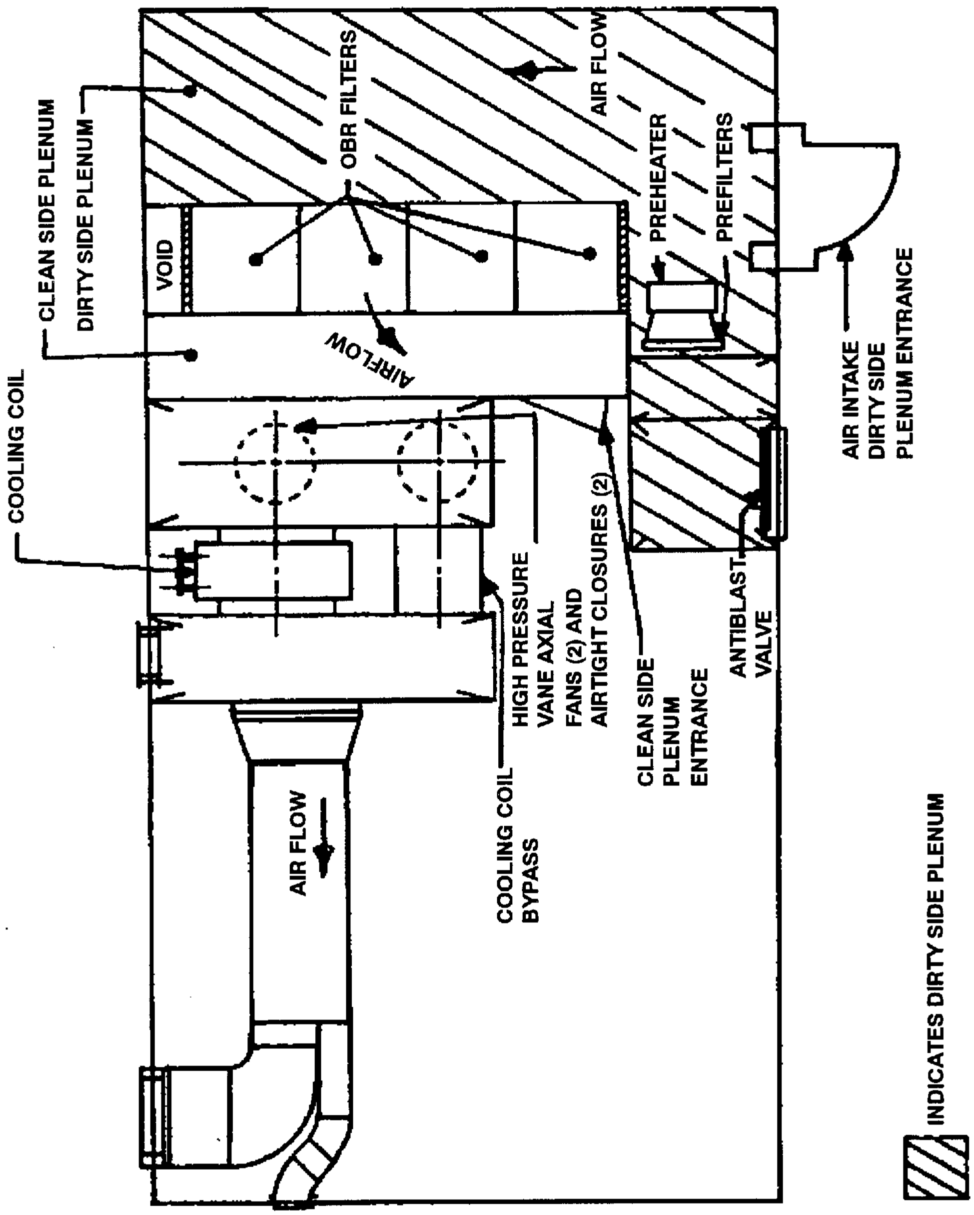


Figure 510-5-1 TP Supply Fan Room Example Layout (Plan View)

510-5.1.2.2 TP Exhaust Systems. Each TP supply system has a companion exhaust system(s) of equal capacity minus the air required for constant sweep for each Type I and Type II airlock and each decontamination station. Navy standard centrifugal fans are used for TP exhaust systems on most ships. A three-position damper is installed in each TP exhaust system. The three-position damper has three settings: fully open, fully closed, and 2 inches WG pressure drop. The three-position damper is used to regulate airflow through the TP exhaust system. The three-position damper should be set in the ″fully open″ position when operating with the TP zone depressurized (at atmospheric pressure). The damper should be set at the ″2-inch WG pressure drop″ position when operating with the TP zone pressurized. The damper should be fully closed when the TP exhaust fan is secured.

510-5.1.2.3 TP Zone Pressure Control. The TP zone is designed to be maintained at 2.0 to 2.5 inches water gage with respect to the weather when zone boundaries are secured and dampers properly aligned. Pressurization within each TP zone is regulated by pressure control valves (PCV). The PCV(s) maintain the pressure of the TP zone between 2.0 and 2.50 inches WG. Additionally, the PCV(s) prevent the TP zone from overpressurizing. The PCV(s) for each TP zone prevent the TP zone pressure from exceeding 3.00 inches WG. For detailed information on the pressurization control valve(s), see NAVSEA Drawing No. 512-6264251.

510-5.1.2.4 TP Zone Pressure Alarms. A CPS zone pressure differential alarm system monitors pressure levels in each protected zone and provides visual indications (colored lights and actual pressure) of each zone's operational, deficiency, and casualty conditions. In the operational mode, this system provides visual indication with a GREEN light when the differential pressure between the pressure zone and the atmosphere is above 1.5 inches WG. In the deficiency mode, this system provides a visual indication with a YELLOW light when the differential pressure between the pressure zone and the atmosphere drops to 1.5 inches WG or below for more than one minute. In the casualty mode, this system provides a visual indication with a RED light when the differential pressure between the pressure zone and the atmosphere drops to 0.5 inches WG or below for more than 15 seconds. These alarms are indicated on a Master Panel located in Damage Control Central (or Central Control Station). A slave panel located in the Pilot House (or Bridge) provides a visual indication with a single RED (Casualty) light for each pressurized zone. The alarm system is in accordance with NAVSEA drawing 512-6264216 or the ship specific damage control console requirements.

510-5.1.3 LP SUPPLY SYSTEMS. LP supply systems filter particulates from weather air with a HEPA (high efficiency particulate air) filter. This provides partial protection from particulate and aerosol contaminants. LP systems do not filter gaseous contaminants, so gas masks are required for protection in LP areas. A typical LP supply system (see Figure 510-5-2)consists of an antiblast valve, a prefilter, a HEPA filter and housing (NAVSEA Drawing No. 512-6263499), a Navy standard vaneaxial fan, and supply system ductwork. The type of HEPA filter and filter housing used is specified in the Ship Information Book.

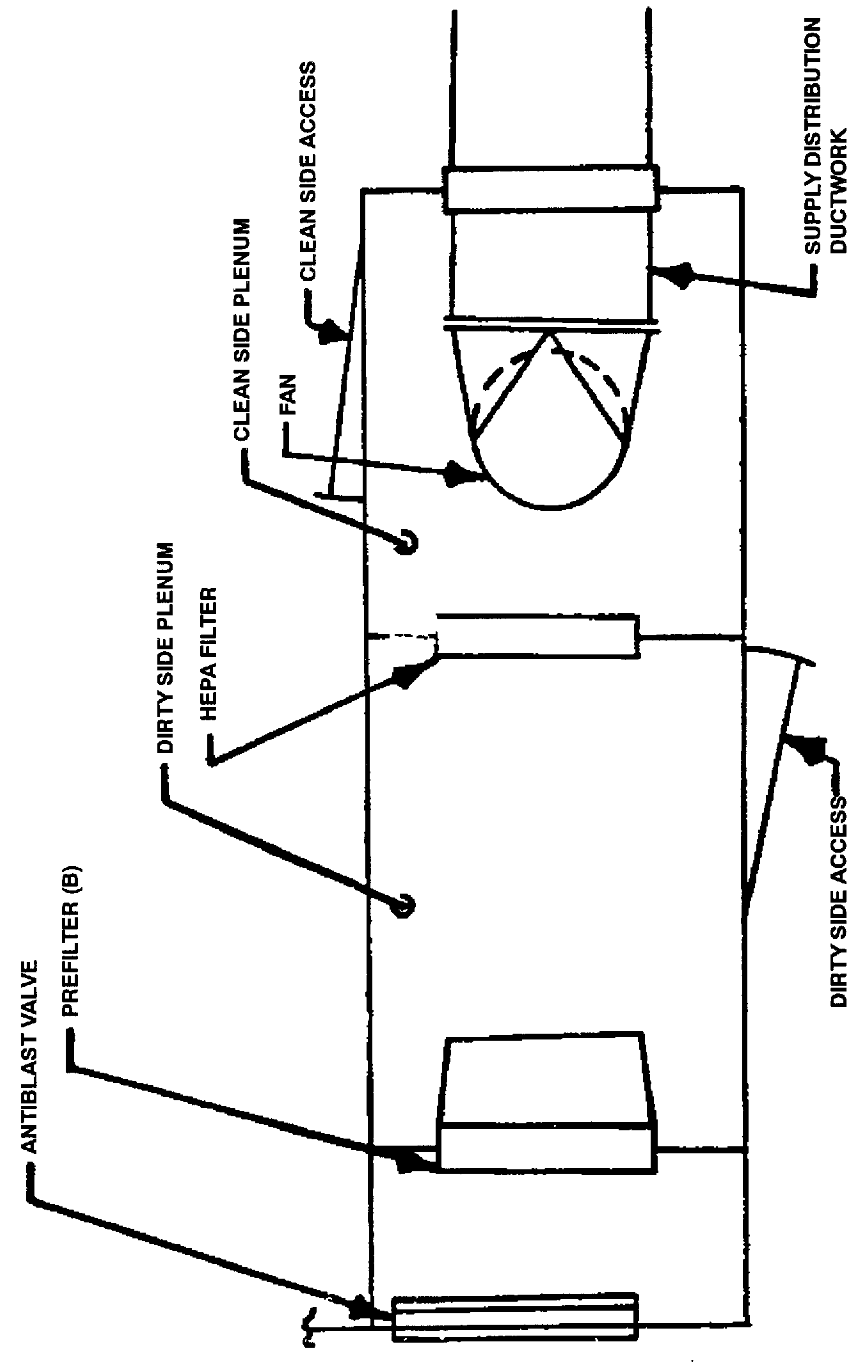


Figure 510-5-2 LP Supply Fan Room (Plan View)

510-5.1.4 ANTIBLAST VALVES. Antiblast valves are used on weather openings to protect ventilation equipment from damage and reduce the possibility of CBR filter failure in case of blast overpressure. The antiblast valve is in accordance with DTRC (David Taylor Research Center) Report C-1339, dated December 1961. Filters on LP and TP supply systems are protected with antiblast valves.

510-5.1.5 CPS DUCTWORK. Limited protection system ductwork does not usually pass through TP zones. When it does, LP ducts are run watertight through TP zones. Ducts that contain dirty air under positive pressure with respect to the weather should not pass through TP zones. Ducts that contain dirty air under negative pressure with respect to the weather are of watertight construction through TP zones. All ducts not containing TP-filtered air that penetrate a TP boundary shall be labeled as a TP boundary. All ducts containing TP filtered air in non-TP areas shall be labeled as a TP boundary.

510-5.1.6 FILTER HOUSING OR FILTER CASING. The CBR filter assembly consists of four major components: HEPA filter, gas filter, aft end assembly, and cover assembly. The filters are housed in a shock and vibration resistant housing that accommodates three filter sets providing 600 cfm of air flow. An illustration of a CBR filter assembly is shown in Figure 510-5-3. The housing is designed to fit into a double bulkhead casing which provides alignment and structural support. The filter housing has two sections, the cover assembly and the aft end housing assembly, each bolted in from opposite sides of the casing. Gaskets provide a permanent seal between the aft end housing assembly, cover assembly, and casing. Two independent covers comprise the cover assembly that seals the charcoal and particulate filters. The HEPA cover seals the particulate filter, and the charcoal cover seals the gas filters. There are two O-ring seals on the cover assembly. They seal the particulate and gas filters so that air cannot leak between the cover assembly and the casing. The covers are held in position with star-shaped hand knobs. All parts of the filter housing are replaceable should any damage occur. For further information see the **CBR Filter System Technical Manual** (SS200-AB-MMO-010).

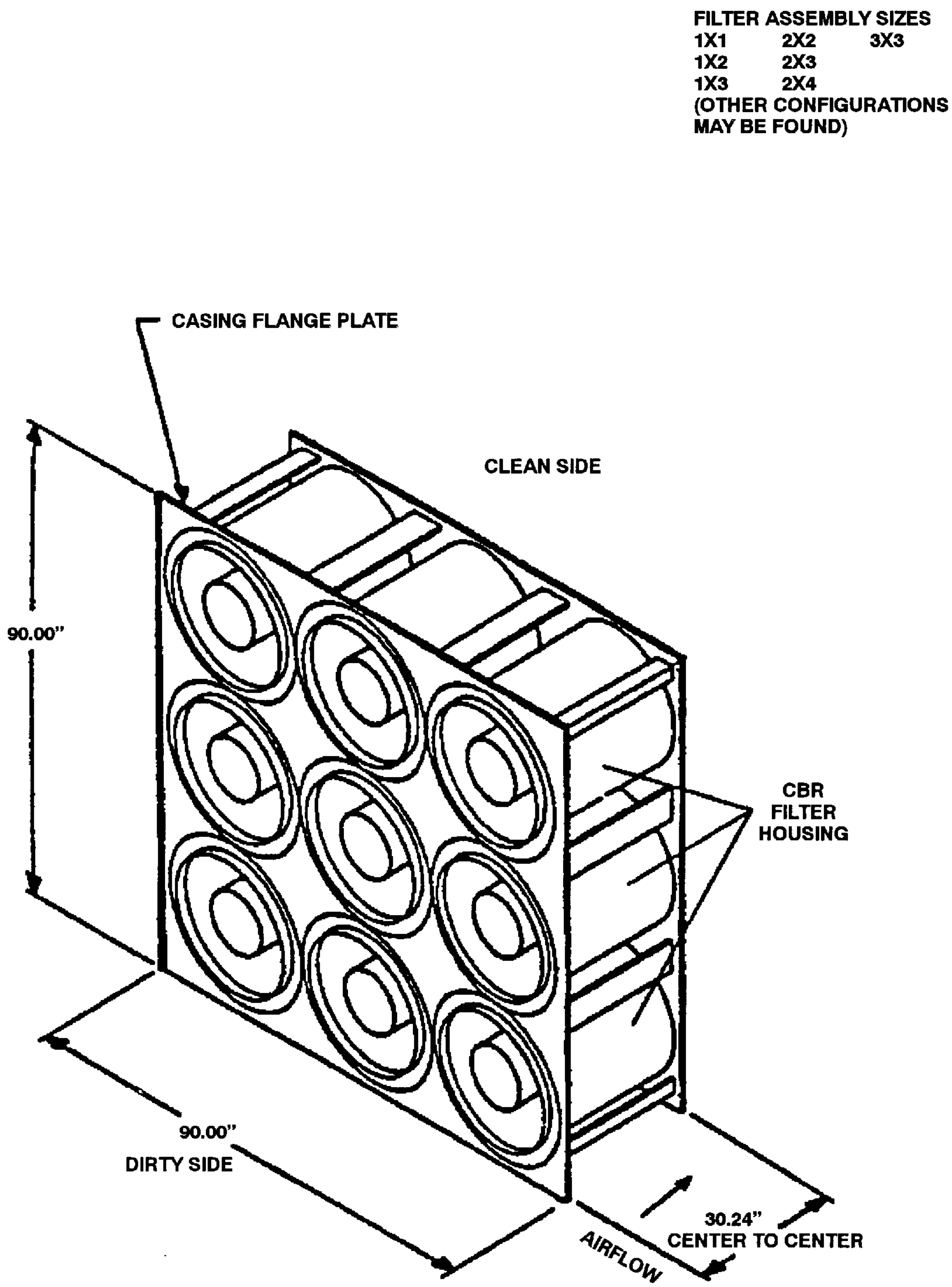


Figure 510-5-3 3 x 3 CBR Filter Assembly

510-5.1.7 HUMIDITY CONTROL FOR CBR FILTERS. To maintain the effectiveness of the CBR filters serving the TP zone, the humidity is controlled to limit the relative humidity to a maximum of 75 percent in the dirty-side air plenum. A humidistat in the TP supply senses the air relative humidity. If the relative humidity is over 75 percent, the preheater is switched on. Preheating the air reduces the relative humidity at the filter bank.

510-5.1.8 GALLEY HOODS. A diverting damper or terminal is installed in each galley in the TP zones. The diverting damper or terminal is manually operated to secure air from the grease interceptor hoods served by the exhaust system. Air is then exhausted from the diverting damper or terminal. This allows the galley hoods connected to the exhaust system to be cleaned without changing the amount of air exhausted from the pressure zone. Recirculation systems with galley hoods are shut down when the hoods are cleaned.

510-5.1.9 TROUBLESHOOTING. Failure to maintain the minimum 2-inch WG in a TP pressure zone degrades the ship's capability to defend against a CBR attack. The TP zone pressure may be read from differential pressure gages located at Type I and Type II airlocks, damage control repair stations, the Central Control Station or Damage Control Central, and Decontamination Stations. Start troubleshooting with a check of all pressurization supply fans to make sure they are operating. If they are operating, check the pressure zone boundary for an open door or hatch to a nonpressurized area. Inspect the prefilter and CBR filter pressure gages to determine if the filters are fouled and require replacement. Inspect the TP supply system ductwork and other supply system components for blockage. The static pressure tap that determines the weather reference pressure must be checked for blockage. Remove all obstructions. Make sure all plumbing and deck drain traps have sufficient water in them to form a proper seal. Check all doors and hatches for proper adjustment and check for damaged gaskets. Check all pressure zone boundaries for air leaks, and repair all leaks found. Cable transits, stuffing tubes, and door gaskets are likely areas for air leaks. Close the diverting damper if necessary. Air leaks may be difficult to find. In some cases leaks can be heard as a whistling noise. A lit cigarette may be used, by using the smoke to determine the direction of air movement. If no leaks are found, the cause of the pressure loss is in the supply or exhaust system. Inspect the three-position exhaust damper (it should be in the intermediate position) and the pressure control valves for proper operation. The pressure control valves should not be open when the zone pressure is low.

SECTION 6.

OTHER ENVIRONMENTAL CONTROL

510-6.1 SAFETY FROM HAZARDOUS GASES

510-6.1.1 CARBON MONOXIDE. Carbon monoxide (CO), a colorless, odorless, and tasteless gas is found in concentrations ranging from 5 to 15 percent in the exhaust gases of internal combustion engines and is a serious hazard to life unless reduced to safe concentrations. During engine warm-up, highly concentrated amounts of CO are released, making this period most dangerous. When CO combines with the body's red corpuscles, the oxygen-carrying capacity of the blood is greatly reduced. A person's blood oxygen content can be reduced to the extent that, while he may be able to remain comparatively quiet and unaware of having absorbed a dangerous amount of CO (because it is odorless and tasteless) he will suddenly collapse if he tries to perform any work or rush to give an alarm. If there is a high CO concentration in a space, the collapse of one person may not give enough warning for others in the space to escape. Multiple injuries or deaths may occur if the precautions in paragraphs 510-6.1.2 and 510-6.1.3 are not followed.

510-6.1.2 CONCENTRATION LEVELS. Safe concentrations of CO vary according to exposure time. The maximum TWA (time weighted average) concentration of carbon monoxide allowed over an 8-hour exposure time is 50 parts per million. Four hundred parts per million is the highest concentration to which workers can be exposed for a period up to 15 minutes continuously without suffering from irritation, chronic or irreversible tissue change, or narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency, provided that no more than four excursions per day are permitted, with at least 60 minutes between exposure periods, and provided that the daily TWA also is not exceeded. See **BUMED Instruction 6270.3** for more information if necessary.

WARNING

Ventilation systems in motor vehicle or tank spaces must be started and operating before any vehicle engines are started.

510-6.1.3 CO CONCENTRATION IN MOTOR VEHICLE HOLDS. Carbon monoxide is a serious hazard in boat wells and in holds where tanks and other motor vehicles are operated. Therefore, adequate ventilation is vital for these areas. For example, in a vehicle stowage space on an LST, an individual would collapse within 7 to 8 minutes if adequate ventilation of the engine exhaust fumes were not provided. After about 13 minutes of engine operation, death might be expected within about 4 minutes, for a person entering from outside. Therefore, since tank motors may idle for one-half to one hour before debarkation, the CO concentration must be kept to a level that will be safe for personnel for periods up to an hour. This concentration is as stated in paragraph 510-6.1.2. **Brief periods of relief to get a breath of fresh air are not sufficient to reduce the CO content in the blood.** Although fatal concentrations of CO may not be present, even smaller concentrations will result in headaches and nausea, thus greatly reducing the alertness and efficiency of vehicle crews. It is necessary therefore that the vehicle space ventilation be operated in such a manner as to minimize the CO concentration. The best way to obtain the lowest possible fume and gas concentration within the vehicle space is to maintain the conditions in the paragraphs that follow.

510-6.1.4 FAN MOTOR VOLTAGE CONTROL. The voltage of fan motors serving motor vehicle holds should be maintained at rated value because low voltage will materially reduce the speed and air delivery of fans. If reduced speed and air delivery occur, an immediate check shall be made to see if rated voltage is applied to fan motors.

510-6.1.5 AIR SUPPLY OPENINGS. Open all the natural air supply openings. These supply openings are located to provide fresh air distribution to all parts of the vehicle stowage space, and if some are left closed, highly concentrated pockets of CO are likely to be formed. On ships with mechanical supply to the vehicle stowage space, the fans should be operated at high speed to provide fresh air to the space.

510-6.1.6 EXHAUST FAN OPERATION. Be sure all exhaust fans are operating. Induced draft from other fans will rotate an exhaust fan fast enough (in the wrong direction) to make it appear to be running. To serve as indicators, cloth streamers may be secured to weather discharge openings. Therefore, when the fans are running, personnel on deck can observe the direction of airflow.

510-6.1.7 RESPIRATORY DEVICES. **The only masks that afford adequate protection against CO inhalation are the oxygen-breathing apparatus and air-line masks.** Oxygen breathing apparatus, being self-contained, protects against all gases as well as a deficiency in oxygen. Similar protection is afforded by air-line masks, that provide a continuous flow of air through the face-piece by way of some outside source, such as compressed air or outside atmosphere. **Although the standard chemical warfare defense gas masks do filter out smoke, none of them afford protection against CO inhalation or oxygen deficiency; therefore they should never be used instead of adequate ventilation.**

510-6.1.8 PERSONNEL INSTRUCTION. All persons concerned with ship operations should become thoroughly familiar with the information contained in paragraphs 510-6.1.3 through 510-6.1.7, as well as with the following instructions:

a. Avoid standing immediately behind or in line with exhaust from any operating vehicles, unless wearing the oxygen breathing apparatus or air-line mask.
b. Any person who develops symptoms of headaches or nausea resulting from exposure to exhaust fumes should leave the space with a minimum of exertion (exertion hastens the action of the gas); remain comparatively quiet in fresh air for an extended period of time; and should avoid exposure to carbon monoxide again for at least another 24 hours.

510-6.1.9 FUEL TANKS. Before entering fuel-oil compartments, gasoline storage tanks, and other normally closed and unventilated spaces, follow the precautions in **NSTM Chapter 074 Volume 3, Gas Free Engineering. NSTM Chapter 541, Ship Fuel and Fuel Systems** , contains instructions pertaining to the proper and safe handling of fuel oil.

510-6.1.10 AIRCRAFT WARM-UP IN HANGARS. An aircraft may be safely warmed-up in aircraft hangar spaces if proper safety precautions are strictly observed. Specific limitations have been established and instructions are separately furnished to all aircraft carriers now in operation. **BUMED Instruction 6270.3F Personnel Exposure Limit Values for Health Hazardous Air Contaminants** shall be adhered to also. Attach flexible exhaust ducts to aircraft cooling system exhaust ports on ships equipped to hangar LAMPS Mark III helicopters.

510-6.1.11 STORAGE BATTERY COMPARTMENTS (LEAD ACID). Storage battery compartments on surface ships have mechanical supply and exhaust ventilation on the basis of a 5.6°C (10°F) rise over outside air temperature, a 6-minute rate of change, or the air quantity required to prevent an explosive hydrogen concentration, whichever is greatest. The quantity of exhaust air required to prevent an explosive concentration is based on the following formula:

V = (0.076) CN

Where:

V = Exhaust air quantity in cfm

C6[]87 = Battery capacity in ampere-hours

N = Number of batteries

0.076 = A conversion constant in cfm per ampere-hours per battery

This quantity of air exceeds that required to maintain a hydrogen concentration of less than 3 percent within the compartment air. If both acid type and alkaline type batteries are stowed in the same space, there shall be an airflow from the alkaline type stowage area to the acid type stowage area. Where batteries are discharged only, special ventilation is not provided. In any location where batteries are charged or discharged, care should be taken to ensure free air circulation over the cells. The battery charger is interlocked with the exhaust fan. This interlock prevents the battery charger from operating unless the exhaust fan is operating. When welding or cutting in battery compartments, batteries should be disconnected and protected from sparks and hot slag. However, care should be taken to avoid covering them too closely thereby cutting off ventilation and trapping explosive mixtures of hydrogen and air beneath the protection cover. When charging portable batteries in spaces other than storage battery compartments, the requirements of **NSTM Chapter 313, Portable Storage and Dry Batteries** apply.

510-6.1.12 ALKALINE BATTERY SHOPS. Alkaline Battery Shops are air conditioned, with exhaust from the space directly to the weather. Exhaust terminals are located over battery charging racks. Where battery racks are enclosed in lockers, ventilation system exhaust ducts are connected to a ventilation exhaust opening at the top of the locker. Large exhaust air quantities are not necessary for alkaline batteries, because alkaline batteries do not generate large amounts of hydrogen when charged. The exhaust system may have a nonsparking centrifugal exhaust fan.

510-6.1.13 ELECTRIC ACTUATORS. Type R and K valves are sometimes installed with electric actuators. These actuators may be actuated with an automatic device, such as a pressure switch, or a manual switch. Manual operation of some valves with electric actuators is only possible when the power to the actuator is shut off. In this case, the actuators are controlled by a two-position snap switch (OPEN, CLOSE). If manual operation of these valves is attempted no damage will occur. However, as soon as the manual handwheel is released, the valve will return to its previous position. Other actuators are wired so that they can be operated manually. These actuators are wired with a two-position momentary contact switch (OPEN, CLOSE) or a three-position snap switch (OPEN, STOP, CLOSE). The two-position momentary contact switch allows manual operation of the valve at all times because the actuator is only energized while opening or closing the valve electrically. This type switch requires that the switch be held to the desired position the entire time the valve is being repositioned. The three-position snap switch operates the same way as the two-position snap switch, except for the STOP position. This position deenergizes the circuit and permits manual operation of the valve. In some Halon systems, the electric actuator is wired so that the valve can be manually operated under all conditions except when Halon is discharged. When Halon is discharged, a relay switch signals the actuator to close the valve. In this case, the open contacts of the actuator are not connected, so manual opening is required after closing by the actuator. At all times other than when the Halon system is being discharged, the valve can be manually operated.

510-6.1.14 SHAFT ALLEYS. Ventilation is provided to shaft alleys to prevent the excessive build-up of noxious fumes, and to ensure an adequate supply of oxygen when shaft alleys contain bearings, fuel oil transfer manifold, drainage manifolds, or other equipment. Where shaft alleys do not contain any bearings, fuel oil transfer manifolds, drainage manifolds, or other equipment, they are considered voids and receive no ventilation. The ventilation system supplying the shaft alley shall be classified ″Circle W″ for those shaft alleys not contained in a TP zone and ″W″ for those shaft alleys which are contained in a TP zone. All closures for the shaft alley are operable from the watch station in the shaft alley.

510-6.1.15 TOXIC GASES AND VAPORS. Many spaces are subject to air contamination from equipment or stored material. Examples of these spaces include Air-Conditioning Machinery Rooms, Gas Cylinder Storage Rooms, CHT Equipment Rooms, Gasoline Pump Rooms, and Oxygen-Nitrogen Producer Rooms. If there is a spill or leak (of materials such as fluorocarbon refrigerants, helium, nitrogen, Halon, hydrogen, or argon) the space shall be certified ″gas free″ before entering without an air-line mask or oxygen breathing apparatus. Low airflow alarms are installed on exhaust systems serving paint mixing and issue rooms, flammable liquids issue and storerooms, flammable gas cylinder storerooms, gasoline storage and handling spaces, and CHT and vacuum CHT spaces. If the ventilation system containing the alarm is classified ″Zebra,″ the alarm will engage when General Quarters is set. If the alarm is disengaged at this time it must be reset at the conclusion of said drill. If there is a low airflow, the cause of the low flow should be determined and corrected without delay. The precautions in **NSTM Chapter 074 Volume 3, Gas Free Engineering** shall also be followed.

510-6.2 DEHUMIDIFICATION OF NONVENTILATED SPACES

510-6.2.1 GENERAL. Where condensation of water vapor on the surfaces of the ship's structure takes place continually, the condensed moisture causes corrosion and increases maintenance requirements. In voids and similar spaces that are opened infrequently and contain nothing which is adversely affected by a dry atmosphere, the effects of condensation can be reduced by dehumidification with desiccants.

510-6.2.2 SILICA GEL. Silica gel, an inert crystalline substance, is the standard desiccant used aboard Naval ships for dehumidifying voids and similar spaces. It is provided in desiccant containers (perforated metal cans 12 inches in diameter and 2 inches thick, containing about 5 pounds of gel). These containers have either an integral cell containing a small quantity of indicator gel, or a humiplug, NSN 6695-00-244-1029. Airtight storage cases, NSN 4440-00-255-9245, each holding eight desiccant containers, are provided for shipment and storage of containers. The chemical and physical composition of silica gel is not materially affected by repeated use, if such use is in accordance with the following directions. A dessicant container and storage case are shown in Figure 510-6-1.

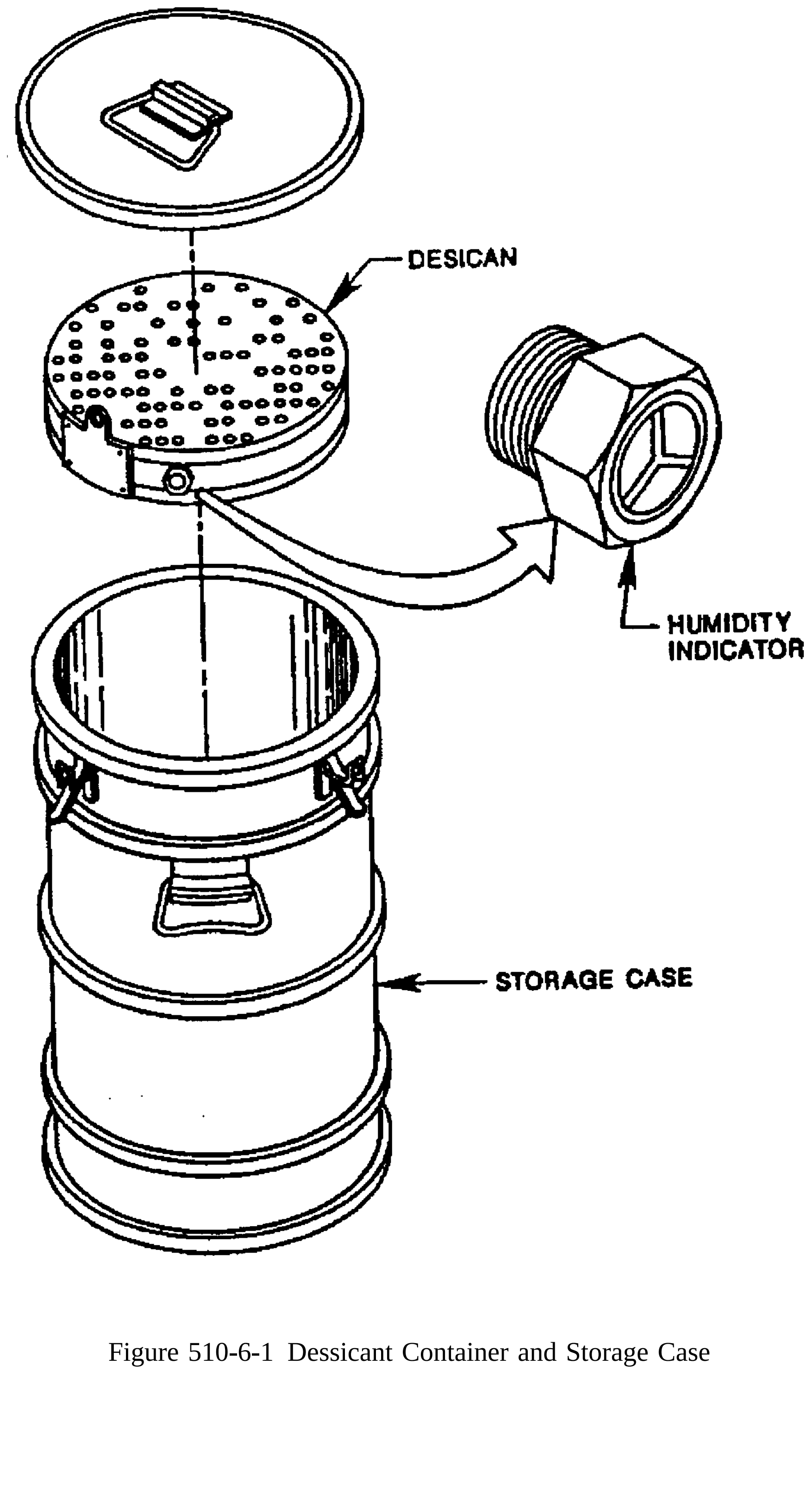


Figure 510-6-1 Dessicant Container and Storage Case

510-6.2.2.1 Areas of Use. Silica gel is used only in spaces where deterioration of structures would result from condensation or high humidity, or where such conditions are anticipated due to the location of the space or the type of boundary. Voids, double bottoms, and cofferdams, which cannot be flooded with water or carbon dioxide, are typical of spaces in which it is used because they are usually damp and subject to high humidity conditions.

510-6.2.2.2 Areas of Nonuse. Silica gel should not be used in spaces that are ventilated or flooded with water, or in such spaces as storerooms where changes of air may occur due to the frequent opening of doors or hatches.

510-6.2.2.3 Supply Quantity. The quantity of silica gel onboard ship should be approximately 10 percent more than required for preservation of voids and similar spaces where means of drying are necessary, as described in paragraph 510-6.2.2.1. This excess permits replacement of the desiccant containers while the spent silica gel is being reactivated in accordance with paragraph 510-6.2.2.6.

510-6.2.2.4 Area Inspection. Before silica gel is used, the spaces to be protected should be carefully inspected for leaks in the plating or in the piping within the space, and repairs made if required.

510-6.2.2.5 Area Approval. NAVSEA approval should be obtained before increasing the number of spaces to be dried by means of silica gel. The request should specify the space number and estimated volume of each space to be dried.

510-6.2.2.6 Reactivation. Silica gel is reactivated by baking in an oven. Containers should be baked for 4 hours at a temperature between 162.8°C (325°F) and 176.7°C (350°F). The humiplug indicator should be removed from the containers so equipped, before reactivation, to prevent damage to the indicating property of the plug at temperatures above 148.9°C (300°F). (The gel in the plug is reactivated by the gel in the container when the plug is reinstalled.) When reactivation is not feasible and where circumstances permit, desiccant containers requiring reactivation, together with their humiplugs and storage cases, may be turned in to shore activities in exchange for activated replacements.

510-6.2.2.7 Inspection of Voids. **NSTM Chapter 079, Damage Control** , requires inspection of voids at specified intervals, and **NSTM Chapter 074, Volume 1, Welding and Allied Processes,** details the precautions to be taken before entering such spaces. Information provided in this paragraph is not to be construed as authority to depart in any way from the instructions contained in the two referenced chapters. When a compartment protected with silica gel has been opened, and after all inspection or work necessary within the compartment has been accomplished, the desiccant containers should be renewed in accordance with the Maintenance Requirement Cards for voids. The need for frequent reactivation of silica gel within a space will indicate the entrance of moist air, which should be investigated and corrected.

510-6.2.3 PORTABLE DEHUMIDIFIERS. Portable dehumidifiers (mechanically refrigerated, self-contained) are provided for use in nonventilated areas such as storerooms, where condensation problems may occur. The dehumidifier removes moisture from the air by condensing the moisture on the surface of a refrigerant-cooled evaporator coil. The air is then passed over the condenser coil, which raises the air temperature slightly above room temperature. The condensed moisture drips from the evaporator coil into a drip pan provided with drain outlet tubes, and passes through the drain outlet tubes into a receptacle that is easily removed for emptying as required. The dehumidifier (NSN 4440-00-691-1292) is designed and manufactured in accordance with ASTM F1075-87 and operates on 115-volt, 60-hertz, single-phase power. Its net weight is approximately 54 pounds, and the moisture removal capacity is 1.8 gallons per 24 hours with space conditions of an ambient temperature of 32.2°C (90°F) and 60 percent relative humidity.

510-6.2.4 COOLING VEST. The cooling vest is used to protect against excessive heat stress. The use of the cooling vest will assist ship's force in being able to withstand heat stress conditions when operational necessity requires the temporary suspension of Physiological Heat Exposure Limits (see OPNAVINST 5100.20C). The cooling vest is a lightweight, adjustable vest into which are inserted up to six thermostrips of plastic ice. It is recommended that ships stock at least 12 Thermostrips for each cooling vest onboard. The Thermostrips will last approximately 2 hours before changeout is required. The Thermostrips absorb body heat, and require refreezing. The ship's freezer can be used to freeze the Thermostrips. Special Thermostrip freezers can freeze Thermostrips in approximately 4 hours, significantly faster than the ship's freezer. The only known manufacturer of this vest is Steele Corp., Kingston, WA.

The following precautions must be observed when using the cooling vest.

a. Clothing, such as a shirt, must be worn under the cooling vest. Although the thermostrips are surrounded by insulation, wearing a shirt will prevent the skin from being in contact with the extremely cold temperatures of the Thermostrip surface.

b. Gloves should be used when handling frozen Thermostrips, particularly those coming from the specialty freezers, which can be extremely cold.

Item	**NSN**	**Model No.**
COOL-VEST	9D 8415-01-289-9797	SA 1140 FR
Thermostrips (6 each)	9D 8415-01-289-9798	SA 1149

SECTION 7.

HVAC CLEANING AND MAINTENANCE

510-7.1 HVAC FILTERS AND ROUTINE CLEANING

510-7.1.1 GENERAL. HVAC systems, with their numerous components (ducts, screens, fans, gratings, heaters, cooling coils, filters, dampers, and others) will deliver their design air quantities and operate at the greatest efficiency only if they are kept clean and functioning properly. As air passes through or over these components, dirt and dust will collect on the various components. Most of this accumulates on the interior of the HVAC system components where it is not readily noticeable.

510-7.1.2 PERIODIC CLEANING. Screens, filters, cooling coils, and duct heaters, particularly preheaters, collect dirt faster than other components of the HVAC system. Laundry exhaust screens are particularly subject to fouling due to the large amount of lint in the air. Ducts, fan blades, fan casings, and other fittings will also accumulate dirt. The amount of air delivered by the system will be reduced considerably by allowing these components to accumulate dirt. Hosing down topside decks in the area of ventilation intakes is one method to reduce the quantity of dirt carried into the system. If this is done, care should be used to avoid spraying water into the ventilation intake. All components of the HVAC system shall be inspected and cleaned regularly in accordance with the PMS cards.

510-7.1.3 FIRE HAZARD CONDITIONS. Dirt accumulations not only reduce the air supply, but they can also constitute a serious fire hazard. The laundry, galley, and machinery space exhaust ducts are examples of locations where this fire hazard is commonly found. A dirty duct will act as a fuse and propagate a flame by igniting accumulations of combustible matter along the duct's length. Periodic cleaning of the HVAC system as specified by PMS cards is a good preventive measure against fires.

510-7.1.4 ACCESS OPENINGS. Access openings are provided in HVAC ducts to facilitate cleaning and inspection of interior surfaces. Access openings are provided as follows:

a. On each side of duct heaters and duct cooling coils, except those duct cooling coils that are directly mounted to modular type electrostatic precipitators. In this case an access shall be provided on the air-leaving side of the duct cooling coil.

b. On the air outlet side of flame arresters.

c. On the inlet side of centrifugal fans, closures, dampers, orifice plates, vaned turns, and splitters.

d. At the impeller end (suction side) of axial fans.

e. In exhaust ducts serving the laundry, galley, scullery, pantry, oxygen and nitrogen producing rooms, machinery spaces, washrooms, toilets, showers, foundries, carpenter, and other shops where dust and air contaminants are produced.

510-7.1.5 ACCESS LOCATIONS. Access openings are generally located on the bottom of ducts and should be within 12 inches of equipment and fittings. Access openings may be located on the side of a duct, if that location is more accessible. When the duct width is less than 6 inches, the access is a removable 24-inch long flanged section of duct. Removable duct sections should be clearly labeled ″REMOVABLE SECTION - DO NOT OBSTRUCT.″ When the duct width is more than 6 inches, the removable access cover plate is approximately the width of the duct and, if the section of duct permits, 24 inches in length. The access cover plate is bolted to the duct to close the access opening in the duct. In exhaust systems serving the laundry, galley, pantry, scullery, oxygen and nitrogen producing room, and machinery spaces, access openings shall be located in such a manner that the interior area of ducts from the exhaust inlet to the weather outlet can be reached and cleaned by hand. A quick-operating cover should be installed in nonwatertight ducts on transitions that are 6 inches or greater in width and should be in accordance with drawing NAVSEA 803-6397256. The quick operating access cover simplifies HVAC component inspection. On some installations, the access cover plate is connected to the duct with a hinge and quick-disconnecting fasteners, rather than being bolted to the duct.

510-7.1.6 GAUZE FOR FILTRATION. Gauze must not be fitted over the supply terminals for use as filters. Gauze not only prevents the passage of dirt and dust, but also restricts the passage of air through the duct. The fact that filtering is necessary indicates that the system should be cleaned. The proper way to reduce the quantity of dirt entering a space from the HVAC system is to keep the ducts clean.

510-7.1.7 DUCT-CLEANING TOOL. Most ductwork may be cleaned with the portable duct-cleaning tool. Any ductwork with grease accumulation (an example is galley exhaust ductwork) should be cleaned by hand, not with the duct-cleaning tool. The duct-cleaning tool has the following major components: a power unit, a flexible shaft connected to the power unit with a rotating plastic head used to dislodge debris in the ductwork, and a vacuum to remove debris from the ductwork. The duct-cleaning tool should be operated as shown in the manufacturer's description, operation, and maintenance instruction technical manual and videotape for the Extraction Systems Inc. Model 3607B Portable Duct Cleaning System (NSN 7910-01-255-1776).

510-7.1.8 CLEANING OF COOLING COILS. Airflow through wet, finned cooling coils onboard ship results in a matted lint and dirt accumulation on the surfaces of the cooling coils. Over time this accumulation will result in a marked decrease of airflow through the cooling coils and, therefore, a large reduction in cooling capacity. Cooling coils shall be inspected and cleaned in accordance with PMS cards in order to provide satisfactory performance.

510-7.1.9 SCREENS. Terminals in the ducts in spaces that may contain explosive vapors or flammable liquids are fitted with eight-mesh aluminum wire screens. Weather and exhaust intakes of ventilating systems are fitted with aluminum or galvanized steel screens of 1-1/2 inch mesh, except when the intake diameter is 9 inches or less or when ratproofing is required, in which cases the screens must be 1/2-inch mesh. Exhaust system intake screens are particularly subject to fouling due to the moisture, lint, grease, dirt, and oil particles present in exhaust air. If an excessive amount of dirt is allowed to accumulate on the exhaust intake screens, the airflow through them is reduced and the space temperature in the ventilated compartment served by the exhaust system will increase. To maintain the required airflow through the screens, they should be cleaned when dirty and as required by PMS cards.

510-7.1.10 FLAME ARRESTERS. Flame arresters, constructed in accordance with MIL-F-17548, are required only in the exhaust ducts from compartments or spaces such as gasoline spaces and aviation fuel shops that contain flammable vapors. Flame arresters consisting of a frame and an arresting cell (screening cell) are installed on the intake side of the exhaust fan outside the compartment or space protected, and in a nonwatertight section of the exhaust ductwork above FWL-II. Navy standard air filters are provided in the casing in front of the arresting cell to reduce the necessity for frequent cleaning of arrester cells, since air filters are more readily removed for cleaning than flame arresters. A flame arrester is illustrated in Figure 510-7-1.

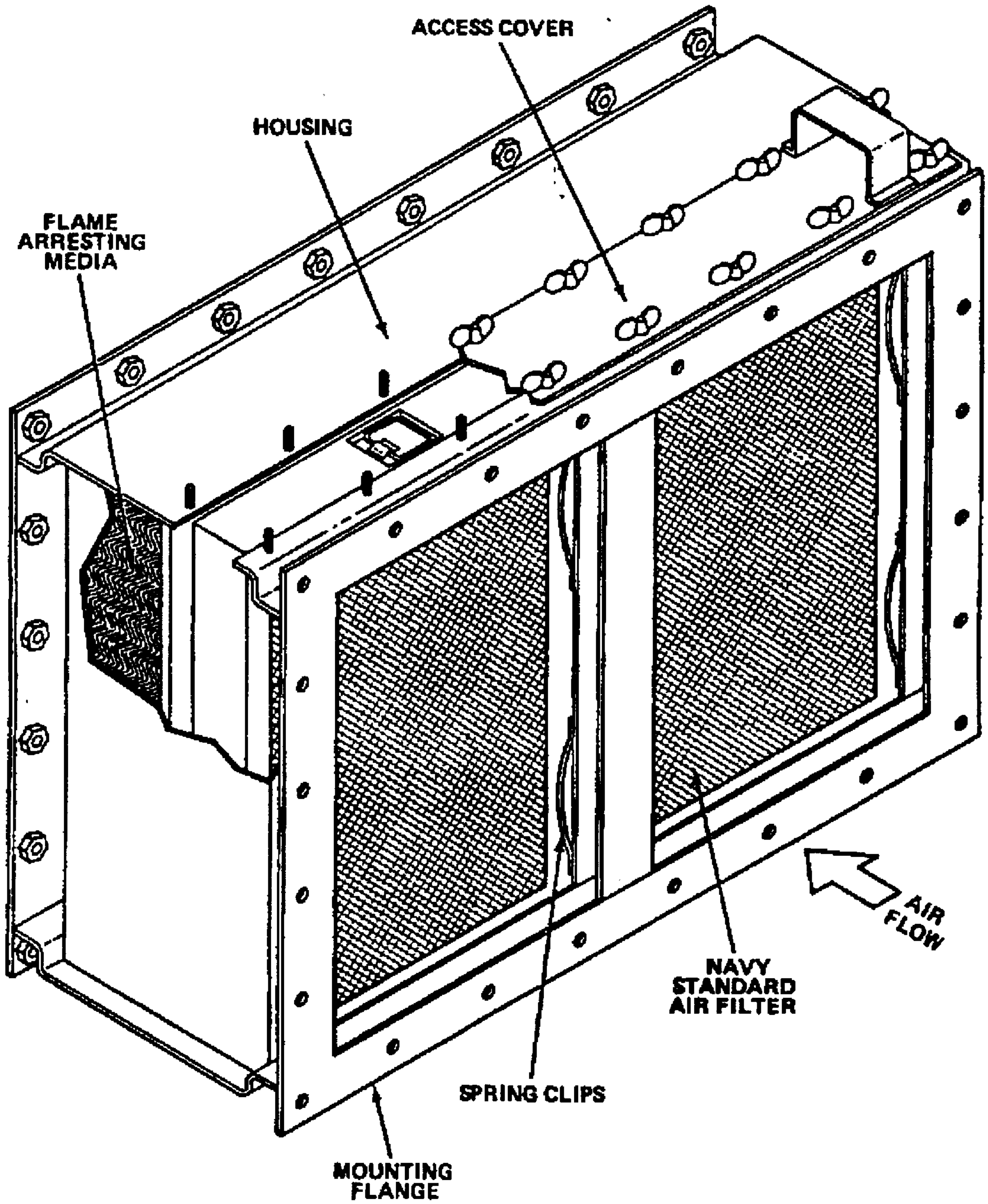


Figure 510-7-1 Flame Arrester

510-7.1.11 FLAME ARRESTER CLEANING. Flame arresters can become clogged with dirt, lint, and other debris, which can decrease the exhaust ventilation airflow rate. Ultimately this may cause a concentration of explosive vapors in the compartment that the flame arrester protects. Flame arrester cells must be cleaned when the pressure loss across the cell increases to twice the loss of the clean cell, as indicated on the differential pressure gage. The flame arrester should be temporarily removed from the ventilation system if the system is to be used for compartment ventilation during a yard overhaul. After cleaning, or removal for any reason, the entire flame arrester assembly should be carefully reinstalled. A poorly fitted assembly, or one with parts missing, can increase the possibility of a fire.

CAUTION

Flame arresters must be removed from ventilating systems prior to painting compartments served by these systems. Accumulation of paint on the cells cannot be dislodged by steam cleaning; thereby the cells are rendered useless and dangerous by the increase in pressure drop across the flame arrester with a subsequent decrease in airflow.

510-7.1.12 ALARM SYSTEM. Gasoline pump rooms, gasoline filter rooms, access trunks to gasoline pump rooms, and enclosed gasoline service stations have flame arresters in ventilation ducts with a circuit HF alarm system, which provides an alarm indication when the exhaust system is secured or blocked. Clean flame arrester cells, air filters, and ductwork will prevent actuation of the circuit HF alarm due to exhaust system fouling.

510-7.1.13 MEASUREMENT OF AIR FILTER DIFFERENTIAL PRESSURE. Some ships have pressure taps on either side (inlet and outlet) of Navy standard air filter banks. By using a portable differential pressure gage, the pressure drop across the filter can be read. When the pressure drop across the filter increases to three times that of a clean Navy standard filter in the same location, the filter should be removed and cleaned. The pressure losses for clean and dirty filters are contained in the HVAC Filter List drawing for the ship. The drawing number may be found in the Ship Information Book. The pressure loss through the filters should be read with the fan operating at proper speed, system fittings clean, and adjustable dampers (if installed) fully open.

510-7.1.13.1 Use of Differential Pressure Readings. When a clean filter is installed at any location, the differential pressure across the clean filter should be that contained in the HVAC filter list referenced in the Ship Information Book (SIB). A reading lower than normal indicates that the airflow rate through the filter is not up to design flow. A dirty cooling or heating coil, malfunctioning fan, or an accumulation of dirt on other fittings can cause this low reading. The closing of adjustable dampers will also cause a low reading. A higher reading usually indicates that the filter was not thoroughly cleaned. Where pressure taps or automatic filter load gages are not installed, procedures on the PMS cards should be followed.

510-7.1.13.2 Automatic Filter Load Gages and Vanes. Automatic filter load gages have an indicator flag that is visible when the filters are dirty and need to be cleaned. On ships equipped with automatic filter load gages, the gages are properly adjusted by the building yard. Gages employing a vane, where the vane position indicates when the filter is loaded, are easily reset when a change in the system or gage requires replacement setting. To reset, install clean filters. All system ducting should be clean, and all dampers should be open. The upper vane is then raised to a vertical position with the indicating vane in a horizontal position. The position of the holding magnet is then adjusted until the indicating vane barely unseats. Bring the upper vane to a horizontal position.

The upper vane uses the pull of the magnet to hold the indicating vane in a horizontal position until the pressure drop across the filter has increased to three times the setting for a clean filter. The gage should need no further adjustment until some change is made in the system.

510-7.1.13.3 Direct Reading Differential Pressure Gages. Systems equipped with CBR or HEPA (high efficiency particulate air) filters have direct reading differential pressure gages to determine the pressure drop across the filters. One filter gage is installed to indicate the pressure drop across the prefilters for CBR filters, and another filter gage is installed to indicate the pressure drop across the CBR filters. CBR filters shall be changed (see paragraph 510-7.1.17) when the pressure drop across dirty filters exceeds 7 inches water gage. On some ships, the differential pressure gages have red and green regions for pressure drops. The green region indicates normal pressure loss through the CBR filters. The red (high) region indicates that the filters are dirty and should be replaced. Most HEPA filters have a differential pressure gage to measure the pressure drop across the HEPA filter. The HEPA filters should be changed as required by PMS cards and the Ship Information Book.

510-7.1.14 NAVY STANDARD AIR FILTERS. Navy standard air filters (manufactured to meet MIL-F-16552) are cleanable, high-velocity impingement type filters. Dirt particles and fine lint in the airstream are collected on the filtering media by adhesion to a thin film of oil (filter adhesive) on the filter. These filters are located upstream of cooling coils, CBR filters, HEPA filters for the LP system, and flame arresters. Figure 510-7-2 shows a Navy standard air filter, and Figure 510-7-3 shows an air filter housing. After cleaning (washing, thorough rinsing, and drying) the filters shall be re-oiled (except air filters used as grease filters in commissary spaces of some older ships should not be oiled). A thin coat of air filter adhesive is applied to the filtering media so that dirt particles and fine lint will adhere to the filtering media. For reoiling after cleaning, any commercial air filter adhesive, other than the type in pressurized (aerosol) spray cans, may be used, provided it meets the following requirements:

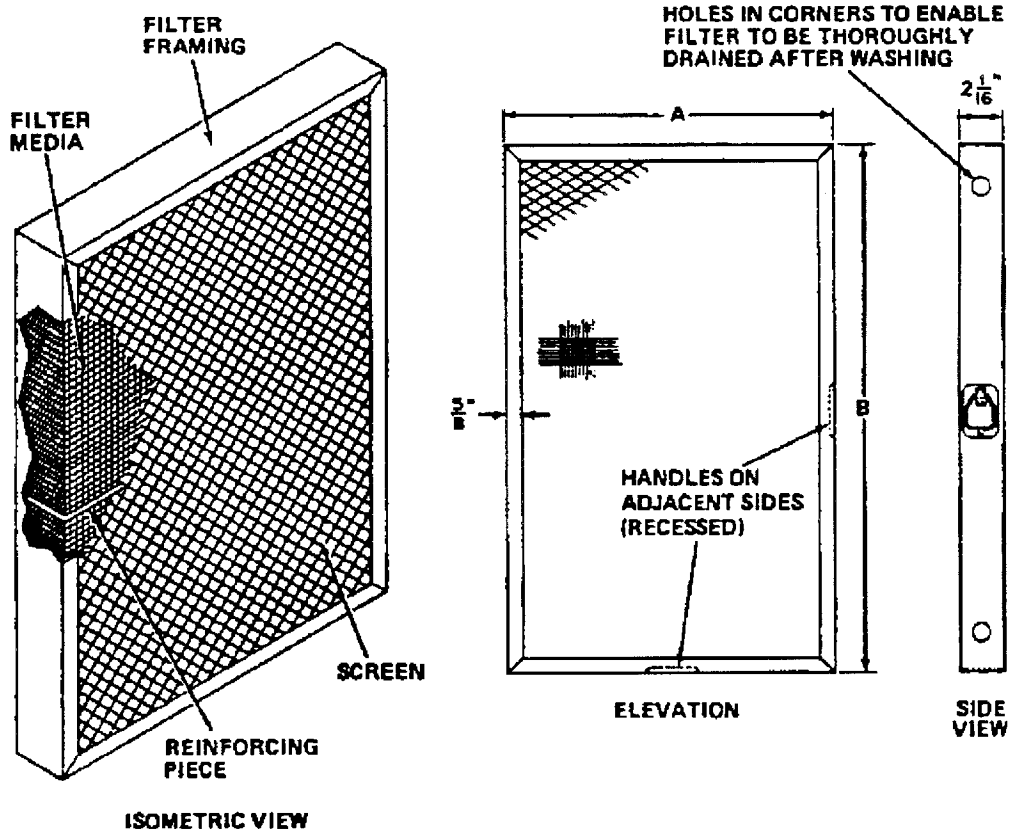


Figure 510-7-2 Navy Standard Air Filter

a. It must be nontoxic, odorless, and water soluble.

b. It must have a flashpoint of not less than 176.7°C (350°F), determined by means of an open cup test.

c. Its viscosity must be such that it can be applied by mechanical spraying at ambient temperatures between 10.0°C (50°F) and 37.8°C (100°F).

Ships are provided with extra filters so that clean filters may be substituted for dirty ones and dirty filters may be cleaned and oiled in batches. Thus, a systematic and regular procedure may be set up to service filters. Navy standard air filters are available in the Navy Supply System. Air filters should be cleaned when required by PMS cards, and as required by paragraph 510-7.1.13.

510-7.1.15 NAVY STANDARD FILTER APPLICATIONS. Cooling coils operate with wet fins, causing them to foul very rapidly, and the cleaning operation is messy and time-consuming. Navy standard air filters are installed upstream of cooling coils to extend the cleaning interval of the cooling coils. Air filters are also used in front of flame arrester cells to prolong as much as possible the time interval between cleaning the cells. When used, flame arresters are essential to prevent possible flame travel through ductwork, and they must be kept free of dirt and lint. Navy standard air filters are used as prefilters upstream of CBR and HEPA filters in the CPS supply systems. The prefilters prolong the life of the CBR and HEPA filters. Air filters are not normally used on ventilating systems.

510-7.1.16 CBR FILTERS. CBR filters filter all weather air to TP supply systems. The filters are designed to remove all chemical, biological, and radiological contaminants. The filters should be replaced when required by the PMS card, and as required by the **CBR Filter System Technical Manual** (SS200-AB-MM0-010).

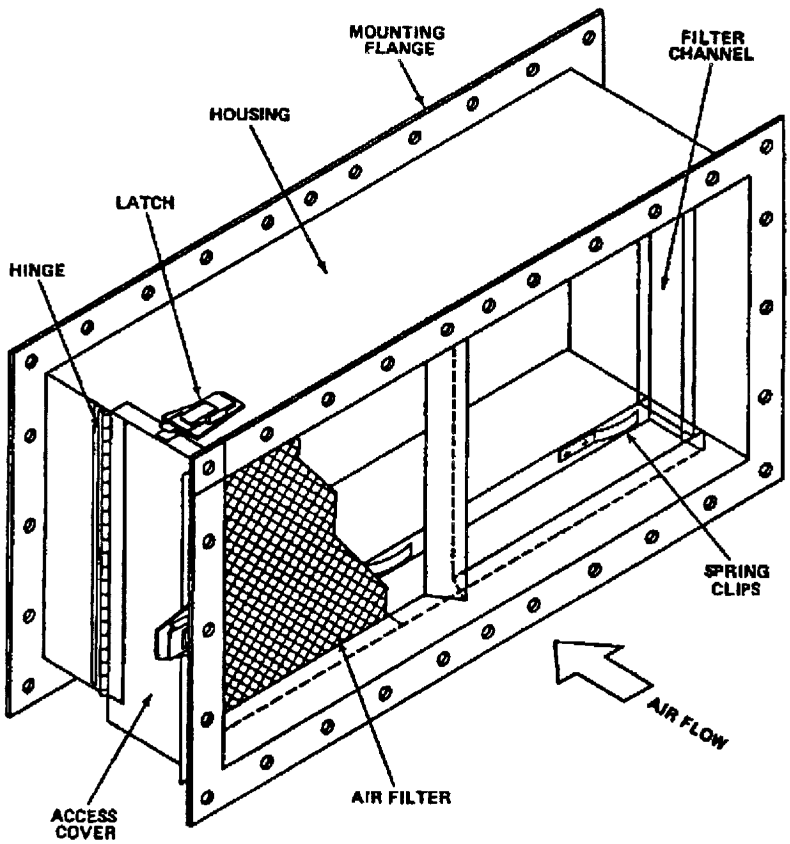


Figure 510-7-3 Air Filter Housing

510-7.1.17 REPLACING CBR FILTERS. The CBR filters should be replaced using the method specified in the **CBR Filter System Technical Manual** (NAVSEA SS200-AB-MMO-010). The following is a general outline for the filter replacement procedure. Enter the outlet (clean side) plenum and install filter housing closure covers with the gaskets against the filter housing. Inspect gaskets to ensure that sealing can be obtained. If a gasket has been damaged, it must be repaired before installing the cover. These covers will prevent contaminated material from entering the clean area from the dirty area during filter replacement. Each filter housing has two O-ring gaskets that must be replaced during each filter replacement. The O-ring gaskets are lubricated and hermetically packaged. One package is marked HEPA Cover Gasket (512-6263430-1) and the other is marked Gas Cover Gasket (512-6263430-2). It is mandatory to install a new O-ring gasket during filter replacement. This is necessary due to the permanent deformation of the O-ring gasket. To ensure proper sealing, the O-ring groove must be cleaned using the groove-cleaning tool (512-6263469). The filters (NSN 4240-01-067-5605) are vacuum packed and must remain this way until used. If a can has been damaged and the seal broken, the filter set must be discarded. The filters should be changed in the order described in the CBR Filter System technical manual. Remove the filter housing closure covers from the filter housing. Store the covers on the closure cover hangers (hooks mounted on the bulkhead). Remove any foreign material that blocks the airflow from the weather deck through the intake to the inlet (dirty side) plenum, particularly at the antiblast valve, prefilter, and preheater. Ensure that supply system ducts are not blocked and that the clean- and dirty-side plenums are not used as storage areas. Remove any stored equipment (unless associated with the ventilation system) or foreign material. When all personnel are out of the plenum, close and dog the door.

510-7.1.17.1 HEPA Filters For LP Systems. HEPA filters are used in LP systems to provide protection from contamination due to chemical and biological aerosols and radioactive fallout. HEPA filters do not provide protection from chemical vapors. The instructions for maintenance and replacement of HEPA filters for LP systems are contained in the HVAC System Manual or Ship Information Book.

510-7.1.18 TEMPORARY IN-PORT FILTERS. Weather air intakes of ships are provided with intake screens (see paragraph 510-7.1.9) that can be used for the attachment of temporary in-port air filters. During yard overhauls and while in port, the weather air intake screens should be covered with filtering material, NSN 9330-00-965-0481. This material is stretched over the screen and secured with cord or wire. The filtering material should completely cover the intake, so that all intake air is filtered. The filter will greatly reduce the amount of dirt and debris entering the ventilation system. The use of temporary in-port filters is extremely important on CBR and HEPA filter intakes for the Collective Protection System. In-port filters greatly extend the life of CBR and HEPA filters by removing much of the dirt and dust from intake air. The temporary filter will slightly decrease the amount of air that comes through the intake. The filter material should be cleaned or replaced when visibly dirty to maintain a clean supply of air to the interior of the ship with a minimum decrease in airflow. The filter material should be replaced if it is damaged. Filters that become clogged with dirt and debris decrease the flow of supply air.

NOTE

These temporary filters must be removed from the air intakes when the ship is under way or when the reduction in airflow causes elevated temperatures in ventilated spaces.

510-7.1.19 GREASE INTERCEPTOR HOODS. The ventilation grease interceptor hood is another type of air filter used in ventilation exhaust systems where a high degree of grease or oil particle removal is required. This type is used primarily in food preparation spaces, but is also used in the air filter service shop.

510-7.1.19.1 Operation of Grease Interceptor Hoods. The grease interceptor hood is a high-velocity, centrifugal grease extractor with a slot-type inlet opening immediately above, and parallel with the top of each item of commissary equipment being served. The smoke, fumes, and vapors (grease and water) that escape during cooking processes mix with the stream of air that blankets the cooking equipment and is drawn into the interceptor hood air inlet. As the hot, contaminant-laden air enters the grease interceptor hood at a speed of 1,000 feet per minute, it is forced to make a series of turns around the baffles. At each turn, the heavier-than-air particles of grease, dust, and lint are ″thrown out″ of the airstream by centrifugal force. The accumulated contaminants are collected in grease gutters within the grease interceptor hood, remaining out of the airstream, until removed daily by the cleaning cycle. The cleaning cycle is activated each time the supply and exhaust fans are stopped by pushing the stop (or start wash) button on the control cabinet located in the galley. Hot detergent water (71.1°C (160°F) minimum and 40 psi minimum) is released into the grease interceptor hood for the length of time preset on the adjustable timer located in the detergent dispenser or control cabinet. For larger galleys, there may be more than one detergent dispenser or control cabinet. The water scrubs the day’s grease, dust, and lint accumulation from the interior of the ventilator and drains by means of a sloping gutter. At the end of the cleaning cycle, the water is automatically shut off. The start (or start fan) button on the detergent dispenser or control cabinet must be pressed to put the fans back in operation. Operating instructions, troubleshooting techniques, maintenance procedures, and safety precautions for the grease interceptor hood are covered in Technical Manual S6161-HAF-SE-010/09051 and Maintenance Requirement Cards.

510-7.1.19.2 Fire Protection for Grease Interceptor Hoods. A fire protection system is provided as an integral part of the grease interceptor hood. When the temperature of the exhaust airstream reaches 121.1°C (250°F) in the ductwork, a fail-safe thermostat will automatically activate the system. The hinged, grease-extracting fire damper (baffle) at the air inlet of the grease interceptor hood closes, preventing flame and hot gases from entering the grease interceptor hood. The exhaust fan shuts off and a water spray (on newer ships) is released. The system can also be activated remotely. If the damper control switch is closed manually, the exhaust fan will not shut off. The damper control switches should always be in the open position under normal operating and washdown conditions.

510-7.1.20 LAUNDRY LINT FILTERS. Exhaust ducts serving tumble dryers in laundries have lint filters or lint traps installed. The lint filters may be an inline removable mesh filter installed on the exhaust duct serving several tumble dryers or a nylon trap installed in the dryer exhaust discharge. Lint filters have a flow sensor that will shut down the dryer if airflow through the filter is high or low. If the dryer will not start, ensure that the filter is clean and installed in the lint filter housing. Lint filters shall be cleaned at least once for every 4 hours of dryer operation or as indicated by the filter gage. In addition to the lint filters, each dryer is equipped with an internal lint filter. These lint filters shall be installed and maintained as specified in **NSTM Chapter 655, Laundry and Dry Cleaning** .

510-7.2 MAINTENANCE

510-7.2.1 OBSTRUCTIONS. Fan rooms must not be used for stowage or office space. Swabs, deck gear, or trash shall not be stowed in fan rooms or HVAC trunks because they restrict the airflow and increase the quantity of dirt and odors taken inboard. HVAC terminals shall not be used for the stowage of clothing, shoes, toilet articles, or any other items. Clothes secured to HVAC terminals will reduce the airflow and, if wet, will increase the moisture content of the compartment air. Deck stowage must be arranged so that weather openings for ventilation systems will not be restricted.

510-7.2.2 OPERATING MAINTENANCE. HVAC equipment (such as fans, cooling coils, fan coil units, and fan coil assemblies) onboard surface ships should be maintained in the best operating condition at all times, in accordance with the detailed instructions in the technical manuals furnished with the equipment. Tampering with the controls or equipment of the system in attempting to improve space conditions should be avoided.

510-7.2.3 TROUBLESHOOTING. Many complaints of inadequate ventilation and requests for HVAC modification are received. Some of these requests are justified, but often the lack of ventilation is due to faulty installation, faulty operation, or inadequate maintenance. A thorough investigation of the HVAC system will often yield remedial measures that are within the capacity of the ship’s force. Unusually hot compartments should be checked in the manner described in the following paragraphs.

510-7.2.4 COMPONENT CLEANING AND INSPECTION. Clean all screens, filters (if installed), heaters, fans, closures, vaned turns, and ducts in both supply and exhaust systems. Dirty system components can greatly reduce airflow. Where natural ventilation ducts are installed, ensure that they are clean and clear of all obstructions. In machinery spaces, check that proper wire mesh screens are installed. If 1-1/2-inch wire mesh screens have been replaced with 1/2-inch wire mesh screens or expanded metal, the airflow will be severely impeded. Install correct screens in place of improper screens. Check weather openings and fan rooms to make sure they are not fouled by stowage.

510-7.2.5 LEAKAGE OR DAMAGE CHECK. Check all ducts for air leaks and for missing, corroded, or damaged sections. Determine whether any additional openings have been made or additional terminals installed. Either condition could deprive other compartments of their design air capacity. Check for damaged terminals or dampers. Repair or replace as necessary. It is possible that condensate drain pans are incorrectly installed on fan coil assemblies, causing leakage around the cooling coil. Drain pans should be installed as shown in Figure 510-4-1 and the fan-coil assembly technical manual.

510-7.2.6 CALIBRATION CHECK. Observe fans for proper rotation direction: motors or fan wheels may have been reversed when reinstalled after overhaul or cleaning. The correct rotating direction is shown on the fan nameplate. Air being discharged from supply terminals and being drawn into exhaust terminals is an indication of proper installation. Check the speed of ventilating fan motors against the rated speed on the nameplate or as listed in the Ship Information Book. Repair as necessary.

510-7.2.7 COMPARTMENT BOUNDARY CHECK. Check compartment boundaries and heat sources within the compartment to see if any surfaces are hot to the touch and whether or not insulation is required. Check all openings into the space to see if hot air is being forced or drawn into the compartment from some other location. Consult the HVAC diagrams in the Ship Information Book to determine the design direction of airflow. Insulation requirements are contained in **NSTM Chapter 635, Thermal, Fire, and Acoustic Insulation.**

510-7.2.8 MACHINERY and HOT SPACE ACCESS CHECK. Check machinery and hot space accesses to see if hot air is being forced out. If so, this indicates a positive pressure within the space. A negative pressure should be maintained in these spaces with all fans (supply and exhaust) either on high speed or on low speed (this does not apply to some older diesel powered ships that draw combustion air from the compartment). Operating the supply fans on low speed and the exhaust fans on high speed to maintain negative pressure is not acceptable. If negative pressure cannot be maintained with all fans at the same speed setting, the cause should be determined and corrected.

510-7.2.9 INSULATION. Machinery or other ventilated spaces that are still excessively warm may either contain sources of considerable heat or the boundaries of these spaces may be exposed to the sun. For such spaces, steam pipe flanges, valve bonnets, and other hot surfaces, as well as ship structures exposed to the sun, should be checked to see that they are insulated in accordance with **NSTM Chapter 635, Thermal, Fire, and Acoustic Insulation.**

510-7.2.10 INSULATION AND TERMINALS FOR MACHINERY SPACES. Installation of the proper type and thickness of insulation is the required treatment for most hot surfaces. Hot spaces, such as machinery compartments, should have large, adjustable air supply terminals capable of delivering 2,000 to 3,000 cfm directly to the watch station. Terminals should be located about 3 to 5 feet from the watchstander's station. The two common deficiencies at these stations are the terminal is installed so that it cannot be properly adjusted for the most effective spot cooling location and hot surfaces are not properly insulated. Flanges and valve bonnets in steam lines and other hot surfaces should be properly insulated. No quantity of ventilation will remove radiant heat. Insulation in accordance with MIL-STD-769 should be installed as required by **NSTM Chapter 635, Thermal, Fire, and Acoustic Insulation.**

510-7.2.11 VENTILATION ALTERATION REQUEST. After troubleshooting a ventilation system and determining that it does not meet the design requirements for temperature, airflow, insulation, etc. (refer to the Ship Information Book), see Section 8 for instructions on how to request a HVAC system alteration.

510-7.2.12 RESPONSIBILITY. Personnel responsible for the operation and maintenance of HVAC systems should perform tasks listed in the following sections.

510-7.2.12.1 Equipment Operation Check. Ensure that all operable pieces of equipment are in good working condition at all times, and that damage control settings can be accomplished. Ensure that every valve that should be classified, from a damage control viewpoint, is classified, and that the classification assigned is the correct one. Ensure that every valve is included in all the checkoff lists on which it should appear. The correct damage control classification for HVAC equipment may be found in the Ship Information Book.

510-7.2.12.2 Modification Check. Ensure that damage control personnel have been made aware of any modification that would compromise the setting of the HVAC system during any material condition.

510-7.2.13 CLOSURE MAINTENANCE. Ensure that all closures are kept clean and free from dirt, debris, and corrosion which could prevent ready closing. All closures should be completely closed periodically to ensure operability in an emergency. Exposed rubber gaskets on type F watertight closures should be kept clean and protected from oil and paint to prevent deterioration. It should be noted that in type F closures, the locking device carries the entire load when the valve is closed against pressure from the underside of the cover. These devices should receive special attention to ensure that they are in good condition. In the closed position, the locking device should be jammed tight. All watertight closures and fire dampers (including Type R and K closures) should have cycled at least twice each month. All moving parts should be lubricated as required by PMS card.

SECTION 8.

ALTERATION REQUESTS

510-8.1 ALTERATIONS

510-8.1.1 No alterations or modifications shall be made to any ventilating or air-conditioning system without prior approval from NAVSEA.

510-8.2 VENTILATION ALTERATION REQUEST

510-8.2.1 GENERAL. To request HVAC system modification, a completed Ventilation Alteration Request Form (Form 510-1) should be sent through the chain of command to NAVSEA. Copies of the form from this manual should be used, if the form is not available in the stock system. When filled out, this request form contains information necessary for NAVSEA to analyze the HVAC system serving the space. NAVSEA will then determine the proper alterations necessary to meet operational requirements. Since the Ventilation Alteration Request is a multipurpose form (used for many aspects of ventilation and air-condition ing alteration requests), only applicable blank spaces need be completed. (It would not be possible, for example, to record cooling coil data when reporting a deficiency in a space being served by a ventilation system.) A separate form shall be submitted for each request and for each space involved. Most of the Ventilation Alteration Request Form is self-explanatory. The following instructions will assist with the sections of the form that are not self-explanatory.

1. The label plate information should include system numbers of HVAC systems serving the space; fan type and size; cooling coil number and size; heater number, size, and type; and damage control classification.
2. The equipment operating in the space should include name plate data of items such as motors, electronic equipment, switchboards, and other heat producing equipment.

3. The description of the problem should be brief. Include any additional information that may assist in solving the problem. Attach extra pages if required.

VENTILATION ALTERATION REQUEST

SHIP	RECORDER NAME	DATE

COMPARTMENT NAME & NUMBER	DATE THE HVAC SYSTEM SERVING COMPARTMENT WAS LAST CLEANED

TEMPERATURES

COMPARTMENT		COOLING COIL			
DB	WB	INLET DB	INLET WB	OUTLET DB	OUTLET WB
°F	°F	°F	°F	°F	°F

SEAWATER	VENTILATION			
	SUPPLY DB	SUPPLY WB	EXHAUST DB	EXHAUST WB
°F	°F	°F	°F	°F

CHILLED WATER		HEATER		WEATHER	
INLET	OUTLET	INLET DB	OUTLET DB	DB	WB
°F	°F	°F	°F	°F	°F

LABEL PLATE INFORMATION

FAN(S)	COOLING COIL	HEATER

VOLTAGE AND AMPERAGE READINGS

FAN(S)	ELECTRIC HEATER

EQUIPMENT OPERATING IN SPACE	CONDITION OF DUCT INTERIOR
	☐ CLEAN ☐ DIRTY ☐ EXTREMELY DIRTY

DESCRIPTION OF PROBLEM

IF MORE SPACE IS REQUIRED, CONTINUE ON SEPARATE SHEET

POINT OF CONTACT	PHONE NUMBER

FORM 510-1. Ventilation Alteration Request

APPENDIX A.

CHILLED WATER SYSTEMS

510-A.1 INTRODUCTION

510-A.1.1 SCOPE. This chapter appendix describes the characteristics, operation, maintenance, and services of the chilled water system and its components. Instructions for the operation, maintenance, and care of air-conditioning cooling coils and other heating, ventilating, and air-conditioning (HVAC) equipment associated with the chilled water system are contained in **Naval Ships' Technical Manual (NSTM) Chapter 510, Heating, Ventilating, and Air-Conditioning Systems for Surface Ships** . Instructions for the operating, maintenance, and care of air-conditioning chilled water plants are contained in **NSTM Chapter 516, Refrigeration Systems** .

510-A.1.2 DEFINITIONS AND LIST OF SYMBOLS. The following terms and definitions apply to surface ship chilled water systems. Also included is Figure 510-A-1, List of Symbols, which defines the symbols used in the figures in this addendum.

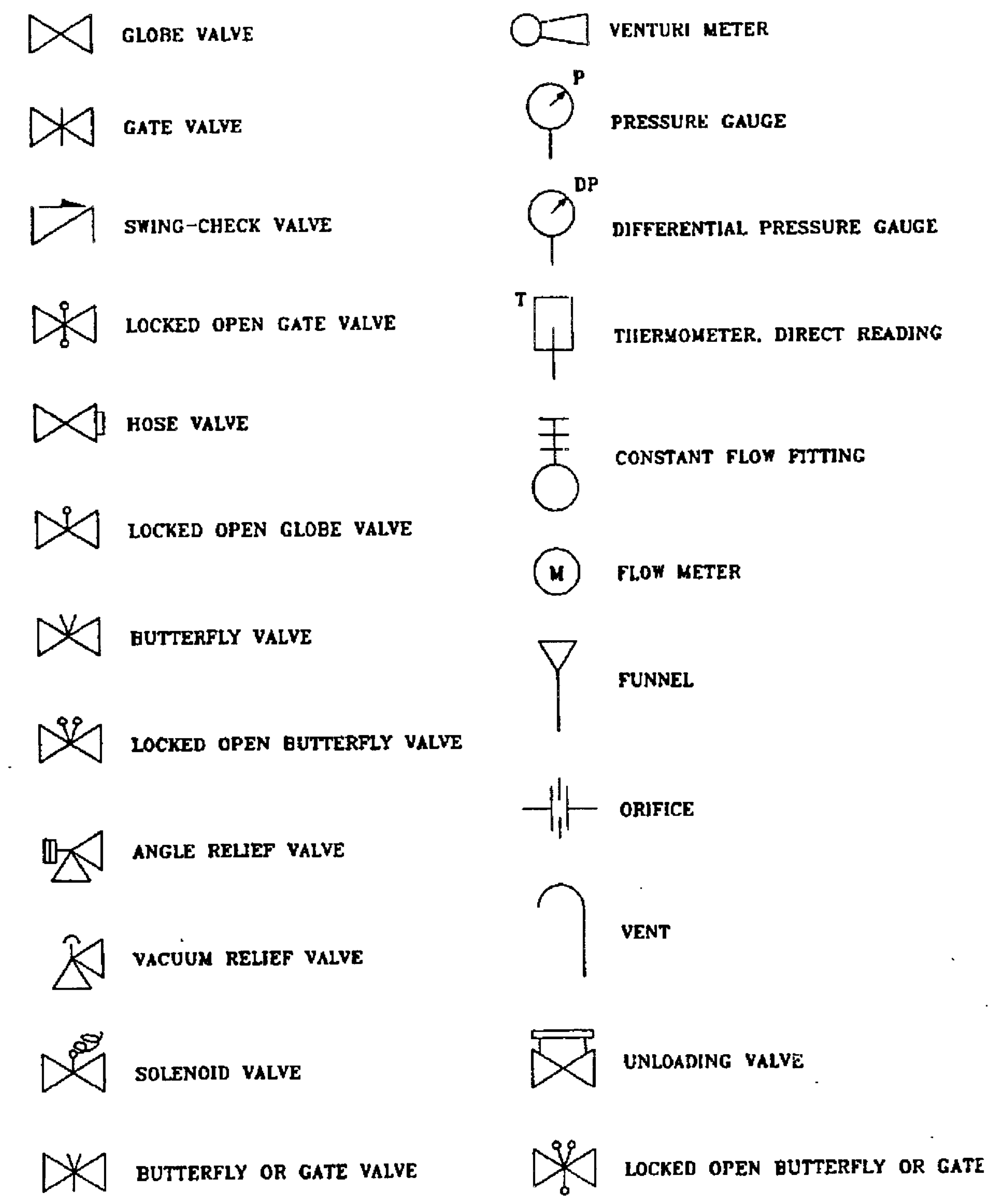


Figure 510-A-1 List of Symbols

510-A.1.2.1 Air Conditioning (AC). The process of treating air to control its temperature, humidity, cleanliness, and distribution to meet the design criteria for a particular space or compartment.

510-A.1.2.2 Air-Conditioning Plant. An integrated set of equipment consisting of a refrigerant compressor, chiller, condenser, and controls that cool fresh water for use as a heat transfer medium.

510-A.1.2.3 Air-Conditioning Plant Capacity Control System. The AC plant control system that adjusts the AC plant heat transfer rate to match that dictated by the plant chilled water flow rate and chilled water thermostat setting.

510-A.1.2.4 Chilled Water (CW). Fresh water cooled to 44°F for use as a heat transfer medium in HVAC cooling coils and equipment heat exchangers.

510-A.1.2.5 Chilled Water Branches. Supply and return piping installed between the equipment served and the mains or cross-connections.

510-A.1.2.6 Chilled Water Cross-Connection. Supply and return piping connecting two separate chilled water zones.

510-A.1.2.7 Chilled Water Mains. Supply and return piping connecting chilled water zones horizontally in the fore and aft direction.

510-A.1.2.8 Chilled Water Plant. The combination of an AC plant(s), chilled water pump(s), expansion tank, chilled water flow meters(s), chilled water supply and return piping, valves, instrumentation, and controls that delivers cool fresh water to the ship cooling coils and heat exchangers.

510-A.1.2.9 Chilled Water Pump. A single-stage centrifugal pump that provides the head necessary for distribution of chilled water throughout the ship; the pump design is typically double suction, horizontally split case, and double volute, with mechanical shaft seals.

510-A.1.2.10 Chilled Water Risers. Vertical supply and return piping from a chilled water plant to a chilled water main.

510-A.1.2.11 Chilled Water System. A closed system consisting of chilled water plants, risers, mains, branch piping, cross-connections, valves, instruments, and controls that supplies 45°F chilled water to HVAC cooling coils, equipment heat exchangers, and other equipment throughout the ship requiring chilled water.

510-A.1.2.12 Chilled Water Zone. Arrangement of supply and return piping from the chilled water plant to the equipment served; a chilled water zone is a complete system that can be isolated from other zones by segregation valves.

510-A.1.2.13 Chiller. The shell-and-tube heat exchanger in a AC plant where heat is transferred from chilled water to the refrigerant. Each heat transfer fluid may be on either the shell or tube side of the heat exchanger, depending on the heat exchanger design.

510-A.1.2.14 Condenser. The shell-and-tube heat exchanger in an AC plant where heat is transferred from the refrigerant to seawater. The seawater flows through the tube side, while the refrigerant flows through the shell side.

510-A.1.2.15 Cooling Coil (CC). An arrangement of finned copper tubes that transfer heat from air flowing over the tubing fins to refrigerant or chilled water in the tubes.

510-A.1.2.16 Damage Control Valve. A strategically placed valve in a piping network that is used for isolating a nearby piping or equipment casualty.

510-A.1.2.17 Expansion Tank. A closed; air-charged pressure vessel connected via a locked-open isolation valve to the chilled water plant return riser. The expansion tank provides space for system fluid volume expansion, collects entrained air, and provides a source of makeup water. It also acts as a surge tank during system resegregation by allowing for fluid transfer and expansion during pump operating point transients.

510-A.1.2.18 Large Combatants. Aircraft carriers, large surface ship combatants (destroyers and larger), and large amphibious warfare ships (LPD and larger).

510-A.1.2.19 Nonvital Loads. Cooling loads that are not essential for ship operation, including air-conditioni ng cooling loads classified ZEBRA. Nonvital chilled water loads are not provided with alternate chilled water branches. The chilled water supplies to nonvital loads are from nonvital chilled water branches.

510-A.1.2.20 Small Combatants. Small surface ships and combatants (frigates and smaller), mine warfare ships, and auxiliary ships.

510-A.1.2.21 Ton of Refrigeration. Heat transfer rate of 12,000 Btu/hr; one British thermal unit (Btu) is the amount of heat required to raise the temperature of a one-pound mass of water one degree Fahrenheit. AC plants are usually rated in tons.

510-A.1.2.22 Vital Loads. Cooling loads that are essential for ship operation, including all air-conditioni ng cooling coils classified WILLIAM, all machinery space services, and all electronic cooling chilled water requirements. High priority vital chilled water loads are supplied from separate, segregated chilled water zones. Vital space cooling loads not essential to the continued operation of combat systems after battle damage are supplied with chilled water from only one zone. Such spaces include magazines, medical spaces, and decontamination stations.

510-A.1.2.23 Zone Alarm. A chilled water zone monitoring system consisting of a thermometer, high temperature switch, pressure gauge, low-pressure switch, 5-gallon per minute (gpm) constant flow fitting, and low flow switch, installed at the most remote vital load in a chilled water zone.

510-A.2 FUNCTION AND BASIC SYSTEM

510-A.2.1 FUNCTION. The chilled water system circulates fresh water to equipment and services requiring cooling water at a temperature for about 45°F. The standard chiller outlet design temperature of new ship chilled water systems is 44°F. The chilled water systems on some older ships were designed to cool the water to 50°F. The system supplies the following equipment requiring cooling water chilled by refrigeration: air-conditioning cooling coils, electronic cooling water systems, deaerating feed tank sample coolers, drinking fountain heat exchangers, propulsion boiler sample coolers, and air compressor heat exchangers.

510-A.2.1.1 Basic System. The basic chilled water system consists of a number of chilled water plants. Each plant circulates chilled water to an associated chilled water zone consisting of supply and return piping from the plant to the equipment served. Each zone makes up a complete circulation system capable of supplying rated flow through all the services in the zone. The zones are cross-connected via fore and aft, single or double mains (described in paragraph 510-A.4.3), such that the plant in one zone can service equipment in other zones in an emergency or during periods of low demand. By using a dedicated refrigerating plant to chill the water and then circulating the chilled water throughout the ship, a large amount of air conditioning and equipment cooling is accomplished with a small amount of refrigerant. This reduces the possibility of losing large amounts of refrigerant in case of a leak and lessens the maintenance associated with direct expansion refrigeration systems. The chilled water system may be used in conjunction with vapor compression refrigerating units using reciprocating, centrifugal, or screw compressors; or with absorption refrigerating units. The components other than the refrigerating units, such as pumps, piping, valves, and cooling coils, are basically the same regardless of the type of refrigerating unit used. The type of refrigerating unit, however, will dictate the selection of certain remaining components in the chilled water system. Current chilled water plant design calls for the installation of centrifugal-type plants in air conditioning systems of 100 tons and up. The principal advantages of a centrifugal compressor over a reciprocating compressor of the same capacity are less weight, smaller size, and less vibration. Another advantage is that the only wearing surfaces are the main bearings since there are no pistons and cylinders to wear.

510-A.2.1.2 Design Objectives. A ship chilled water system is designed to provide maximum flexibility under all operating conditions. The following objectives form the basis of the design:

a. Operation of the minimum number of chilled water plants in any combination to meet the required cooling loads under all operating conditions.
b. Operation of all chilled water plants independently under battle conditions with zone segregation valves closed.
c. Operation of the minimum number of chilled water plants required to serve the vital loads, with the proper segregation valves closed and no degradation of service to any vital load.

510-A.3 SYSTEM CONFIGURATIONS

510-A.3.1 CHILLED WATER PLANTS. Chilled water plants are configured as shown in NAVSEA drawing 804-1385801. Chilled water plants may be arranged singly or in a dual configuration. Separation of plants for survivability is discussed in paragraph 510-A.4.2.

510-A.3.1.1 Single Plant. Figure 510-A-2 shows the configuration of a single chilled water plant. The chilled water circulating pump takes suction from the chiller and discharges to the supply riser in the circulation loop. After circulation through the equipment served, chilled water is returned to the chiller where it is cooled to 44°F. An expansion tank is connected via a locked-open isolation valve to the plant return riser ahead of the chiller inlet isolation valve. It allows for expansion of the chilled water when the plant is secured and the water temperature increases; it also provides a source of makeup water. The expansion tank is charged with compressed air to maintain a minimum pressure of 5 psig at the chilled water pump inlet under all operating conditions. A recirculation line is installed at the chilled water pump discharge. The recirculation line is fitted with an orifice sized to protect the pump from overheating if the pump is ever operated with the pump discharge valve closed. The recirculation line returns water to the inlet side of the chiller. When centrifugal or screw-type compressors are installed, an unloading valve is used instead of an orifice. The unloading valve is sized and set to maintain the minimum required flow necessary to prevent chiller shutdown during low chiller chilled water flow, and to protect the chilled water pump from overheating if the pump is operated with the pump discharge valve closed. Typically the chiller low chilled water flow switch is set to deenergize the AC plant compressor at a chilled water flow rate of one-third of design flow rate.

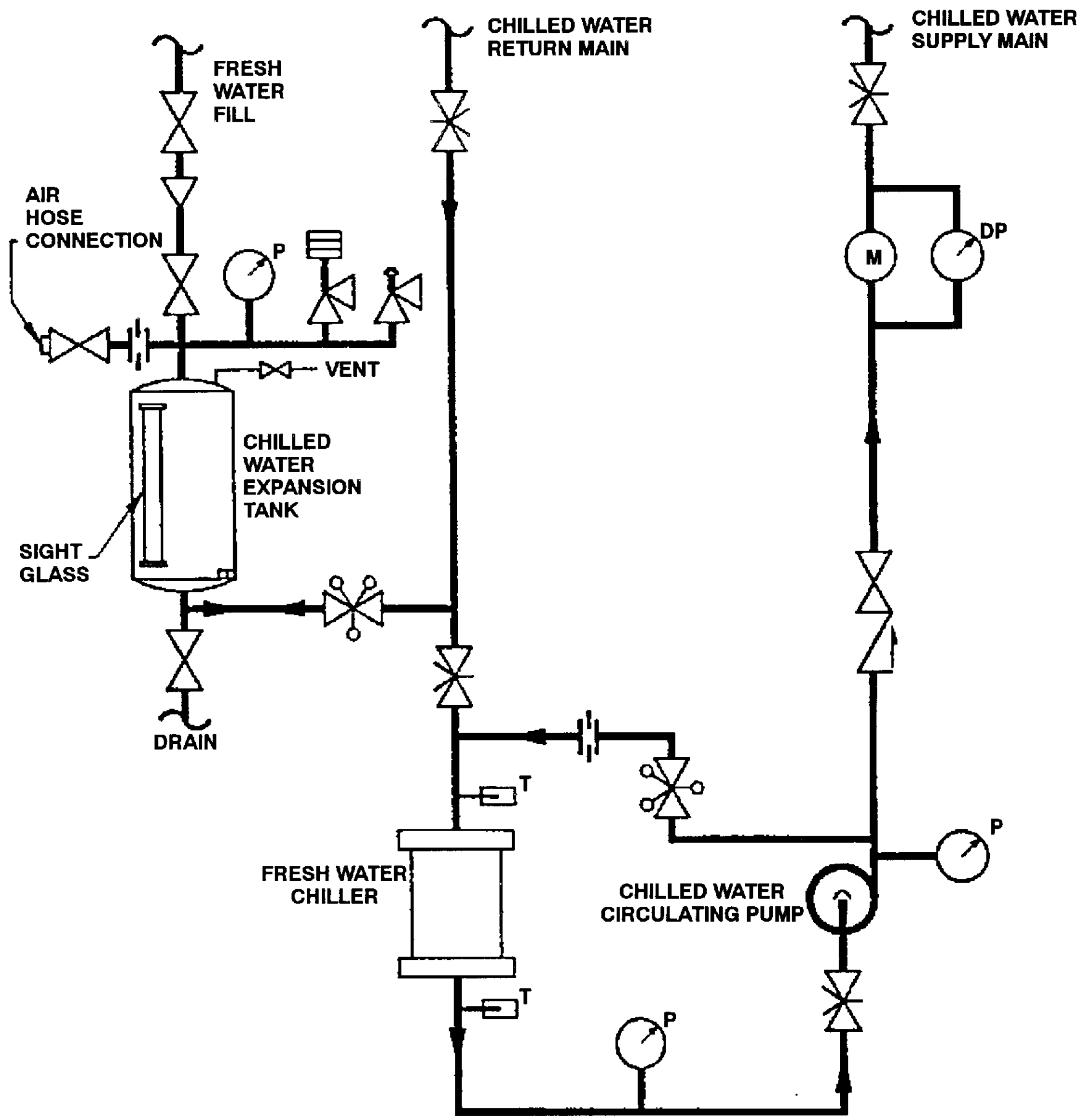


Figure 510-A-2 Single Chilled Water Plant Configuration

510-A.3.1.2 Dual Plant. Two chilled water plants located in the same space can be installed either as independent plants with a cross-connect capability or as a combined plant with common supply and return mains. Figure 510-A-3 shows the arrangement of two separate plants in the same space with cross-connects between the chilled water circulating pump suctions and discharges, and between the return lines to the chillers. Normally, the cross-connections between the two would be shut and the plants operated independently of each other. If one of the two plants in the same space is down for maintenance or not needed to meet the chilled water demand, the cross-connects provide a means of using the chiller or circulating pump in the idle plant as a backup for units in the operating plant. For example, if the pump in the operating plant fails, the cross-connections between pump suctions and pump discharges can be opened and the pump in the idle plant used in its place. Figure 510-A-4 shows a chilled water plant arrangement where two chillers and two circulating pumps have been placed in parallel to form a single plant with double chillers and pumps. The two pumps discharge to a common header, and each pump is provided with a recirculation line back to the common inlet to the two chillers. A single return line to the chillers enables the use of a single expansion tank. The chiller bypass line provides for reduced cooling capability if one chiller is inoperative. The bypass is designed to handle 50 percent of the normal total chilled water capacity of the combined system. This arrangement can be used where space restrictions do not permit installation of two independent plants with separate expansion tanks.

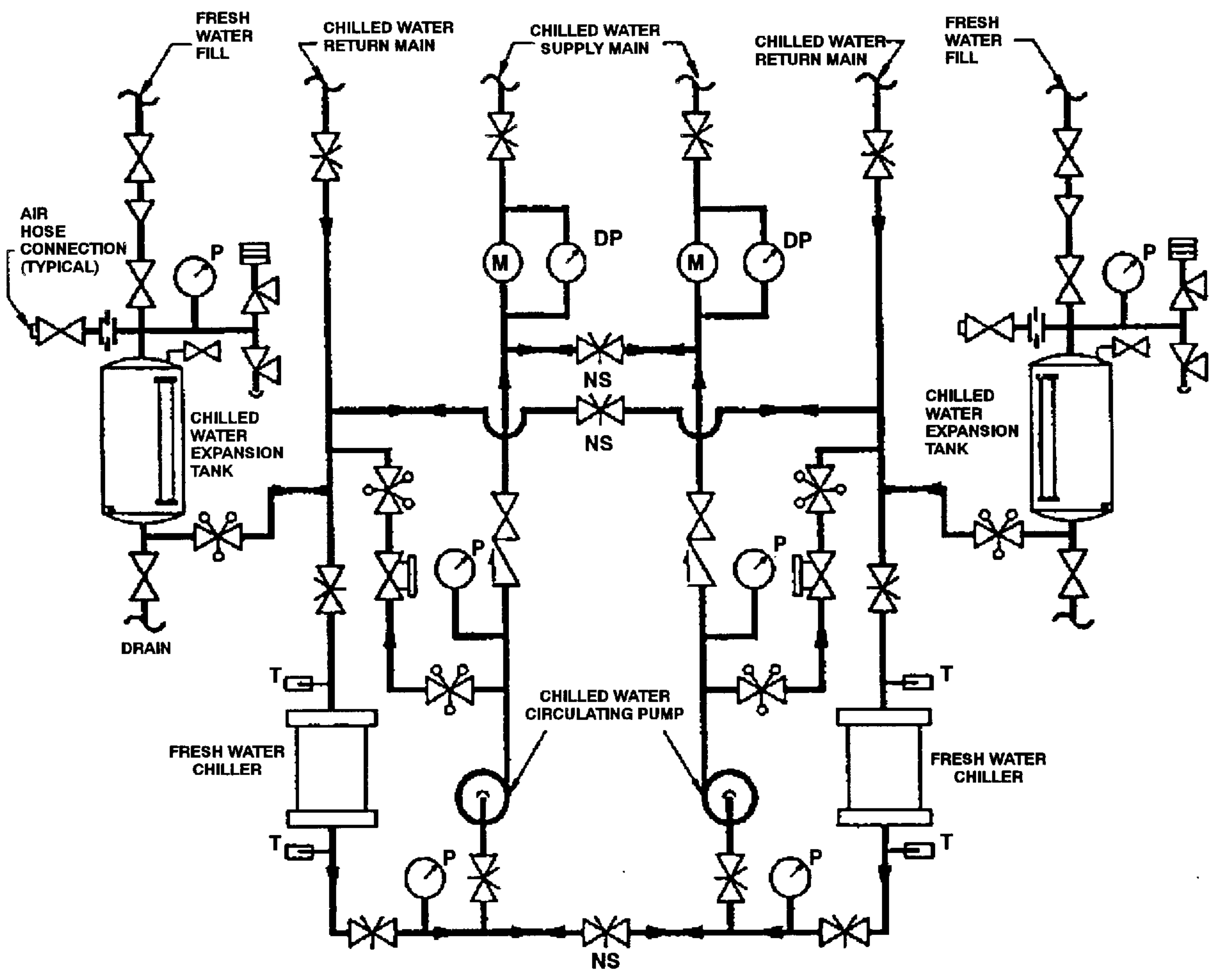


Figure 510-A-3 Two Chilled Water Plants in Same Space and Cross-Connected

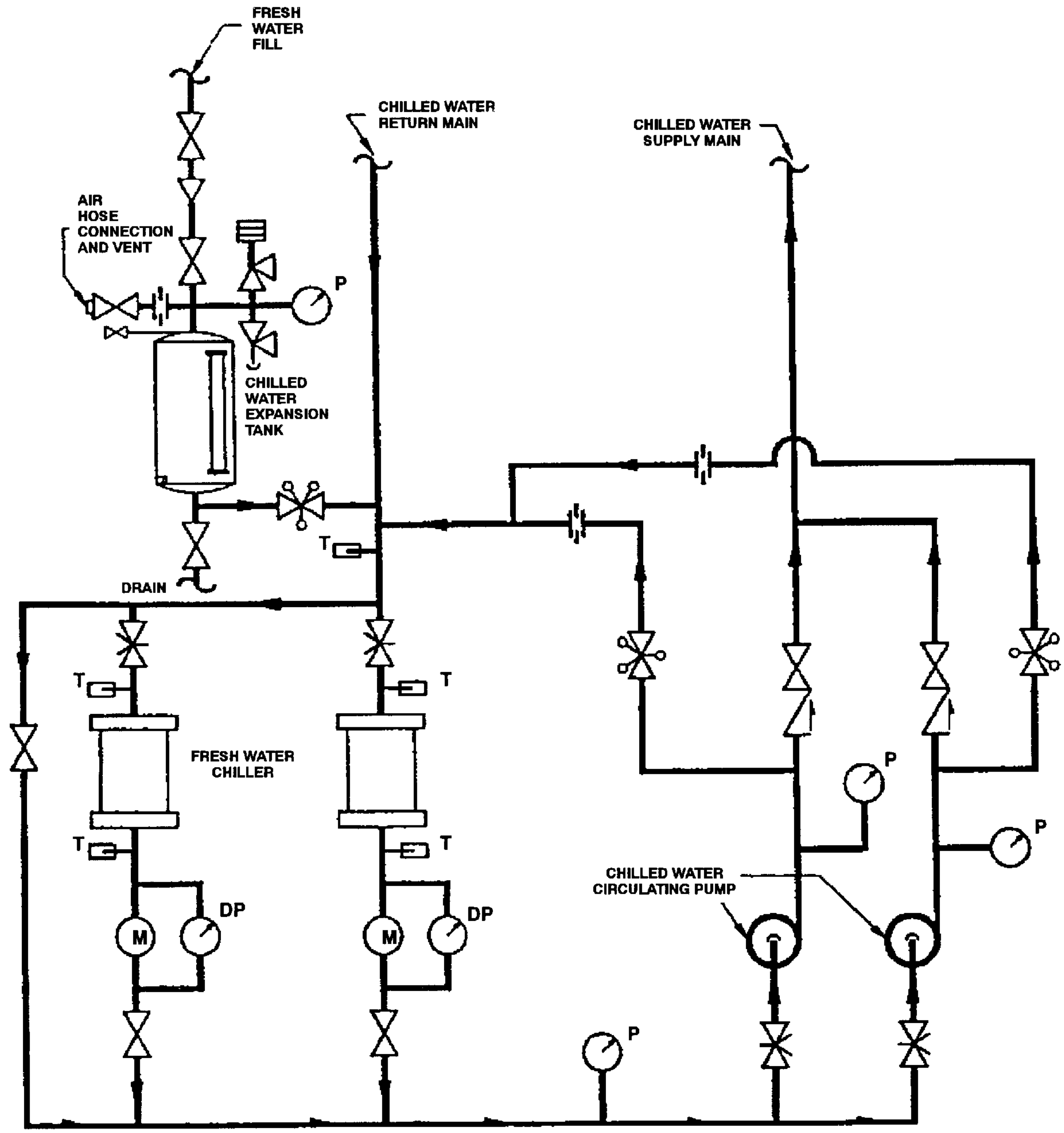


Figure 510-A-4 Chilled Water Plant with Two Circulating Pumps and Two Chillers

510-A.3.2 CHILLED WATER DISTRIBUTION.

510-A.3.2.1 Mains, Risers, Cross-Connections. Double main systems are provided on large combatants, arranged typically as shown in Figure 510-A-5. Paragraph 510-A.4.3 discusses location and separation of the mains for survivability. The mains normally extend the length of the deck that contains the major connected loads; the ends of both mains are connected to form a loop. Chilled water plants are connected to the mains by supply and return risers from each plant. A cutout valve is installed in each riser at the connection to the main and in the mains on each side of the riser. Generally, a chilled water cross-connection is provided between double mains at the location where a riser connects to a main. Cross-connections, however, are not normally provided at risers located near the ends of the mains, where the mains are connected to form a loop. A cutout valve is installed at each end of a cross-connection where it connects to a main. Segregation valves are installed in mains to divide the connected load into approximately equal zones. In general, a chilled water zone is provided for each chilled water plant. On small combatants and auxiliary-type ships, only a single main is provided on or near the damage control deck. Figure 510-A-6 shows a single main system. The criteria for length of the main, connection of chilled water plants, and segregation into zones is the same as for double mains.

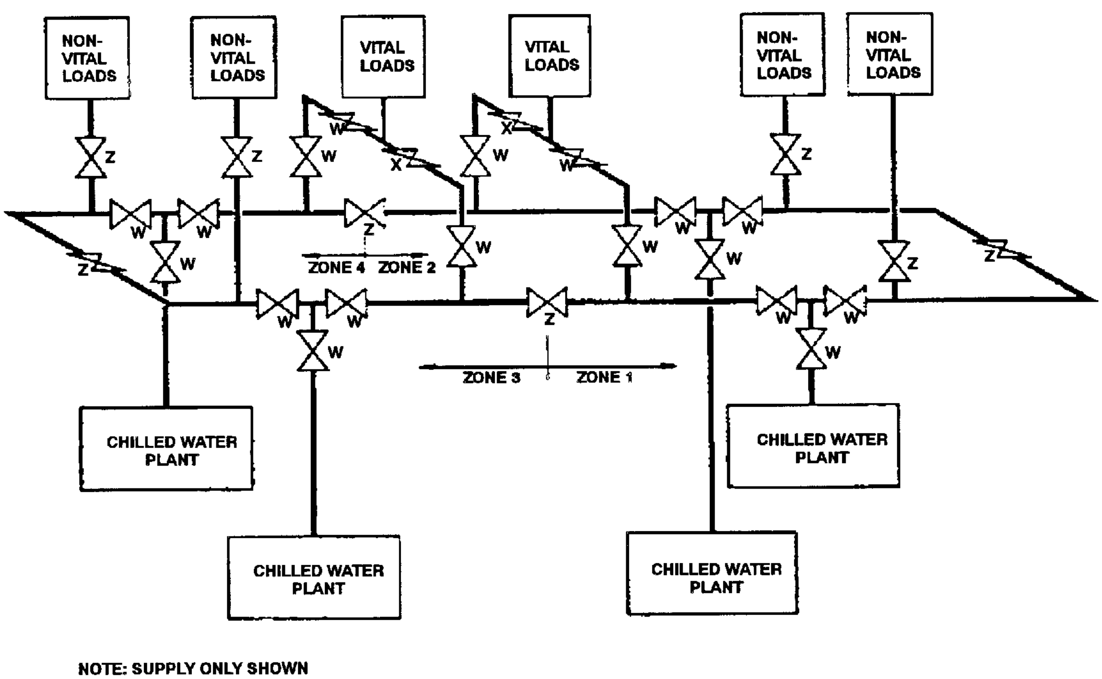


Figure 510-A-5 Chilled Water Double Main System

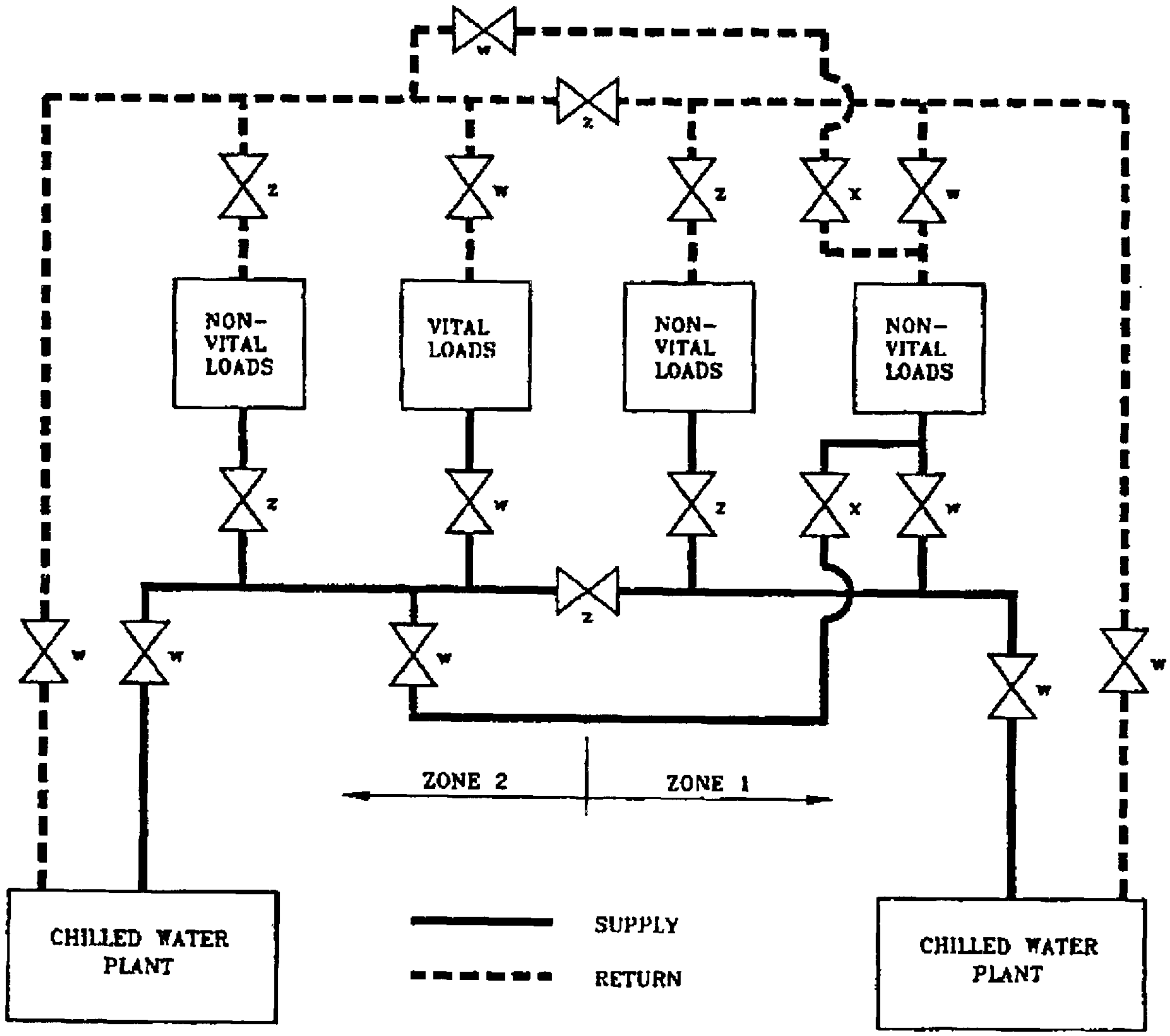


Figure 510-A-6 Chilled Water Single Main System

510-A.3.2.2 Service Branches. Branches to chilled water services run from the mains and from the cross-connections. Root cutout valves are installed in all branches as close to the mains or cross-connections as practical. These valves are classified WILLIAM or ZEBRA, depending on the service. Service branches classified WILLIAM supply vital loads, while service branches classified ZEBRA supply nonvital loads. Nonvital loads are grouped, to the maximum extent possible, to reduce the number of valves to be closed during General Quarters. WILLIAM and ZEBRA valves are not grouped together into a single branch from the main to prevent inadvertent cutoff of vital loads. Chilled water service branches are sized to carry a flow of 4.5 gallons per minute per ton (gpm/ton) of AC plant tonnage. Each cooling coil is sized for approximately 3.6 gpm/ton of cooling coil tonnage. The 25-percent margin (0.9 gpm/ton) is provided for future load increases and to ensure that the cooling coils located farthest away from the chilled water plant are provided with adequate pressure.

510-A.3.2.3 Chilled Water Segregation Valves. The segregation valves between zones are classified ZEBRA and are closed during battle conditions. The valves may be opened to supply WILLIAM services in an adjacent zone, if necessary. Damage control valve locations are selected such that a minimum number of valves are required to protect WILLIAM services. In general, the maximum number of WILLIAM service branches between damage control valves is three.

510-A.4 SURVIVABILITY

510-A.4.1 OPERATING MODES. Distinct material conditions of readiness as defined in **NSTM Chapter 079, Damage Control,** are maintained during each ship operating mode to define the degree of chilled water system closure and limit the extent of system damage in a casualty. The three ship operating modes that affect the operation of the chilled water system are NORMAL, GENERAL QUARTERS, AND CASUALTY.

510-A.4.1.1 Normal (Conditions X-Ray and Yoke). Either condition X-RAY or YOKE may be set during normal operating conditions. Chilled water system valves and other closures that are to be closed or secured during condition X-RAY are labeled ″X.″ Chilled water system valves and other closures that are to be closed or secured during condition YOKE are labeled ″X″ or ″Y.″

510-A.4.1.2 General Quarters (Condition Zebra). Condition ZEBRA is set prior to going to sea or entering port during wartime, when manning General Quarters stations, and to localize and control fire and flooding when not at General Quarters stations. Chilled water system valves and other closures that are to be closed or secured during condition ZEBRA are labeled ’X,″ ″Y,″ or ″Z.″

510-A.4.1.3 Casualty. Action is taken during a casualty to maintain chilled water service to vital (WILLIAM) loads. Damage may occur to either the chilled water plants or a portion of the chilled water distribution system. If a chilled water plant is unable to function due to a casualty, it is secured and its loads supplied by the remaining chilled water plants. If there is insufficient chiller capacity to maintain 45°F water to the ship vital loads, nonvital (ZEBRA) loads are secured. If a portion of the chilled water distribution system is damaged, the damaged area is isolated and chilled water is routed to the affected loads via an alternate path.

510-A.4.2 PLANT SEPARATION. Redundant plants are normally installed in separate compartments, and the system is arranged such that vital services can be supplied after the loss of any plants located within a damaged zone. Current design philosophy is to separate air conditioning plants so that, in the event of losing an AC machinery space, the surviving number of plants can satisfy the vital load.

510-A.4.3 SEPARATION OF MAINS.

510-A.4.3.1 Double Mains. On large combatants, the chilled water zones are cross-connected to form two chilled water mains in the fore and aft directions. Double mains are separated athwartship and usually vertically as well. Athwartship separation is achieved by locating port and starboard mains within six feet of the most outboard structure. Vertical separation is achieved by separating the port and starboard mains by a minimum of one deck and by two decks where possible. One main is normally located on the damage control deck.

510-A.4.3.2 Single Main. On small combatants and auxiliary ships, a single chilled water main is installed on or near the damage control deck. The main is usually run within 10 feet of the ship centerline.

510-A.4.4 SERVICE BRANCH CONNECTIONS. Segregation valves are installed in the chilled water mains so that the connected loads, both vital and nonvital, can be divided into segregated zones. Service branches connect the mains to the loads; a root valve is installed in each branch where it connects to the main.

510-A.4.5 VITAL LOADS. On combatants, a vital space cooling load served by a single cooling coil or heat exchanger is usually supplied chilled water from two separate, segregated zones, as Figure 510-A-7 shows. The two supply branches are cross-connected at the load. The primary branch root cutout valve and load cutout valve are classified WILLIAM and are labeled ″W.″ The alternate branch root cutout valve is classified WILLIAM, and the alternate branch load cutout valve is classified X-RAY and labeled ″X,″ allowing switching to the backup zone at the user. A vital space cooling or electronic cooling water load served by two cooling coils or two heat exchangers is supplied chilled water from separate, segregated zones on combatants, as Figure 510-A-8 shows. The two branches are not cross-connected. Vital space cooling not essential to continued operation of combat systems after battle damage are supplied chilled water from only one zone. Such spaces include magazines, medical spaces, and decontamination stations. On noncombatants, vital space and electronics cooling systems are supplied from only a single zone.

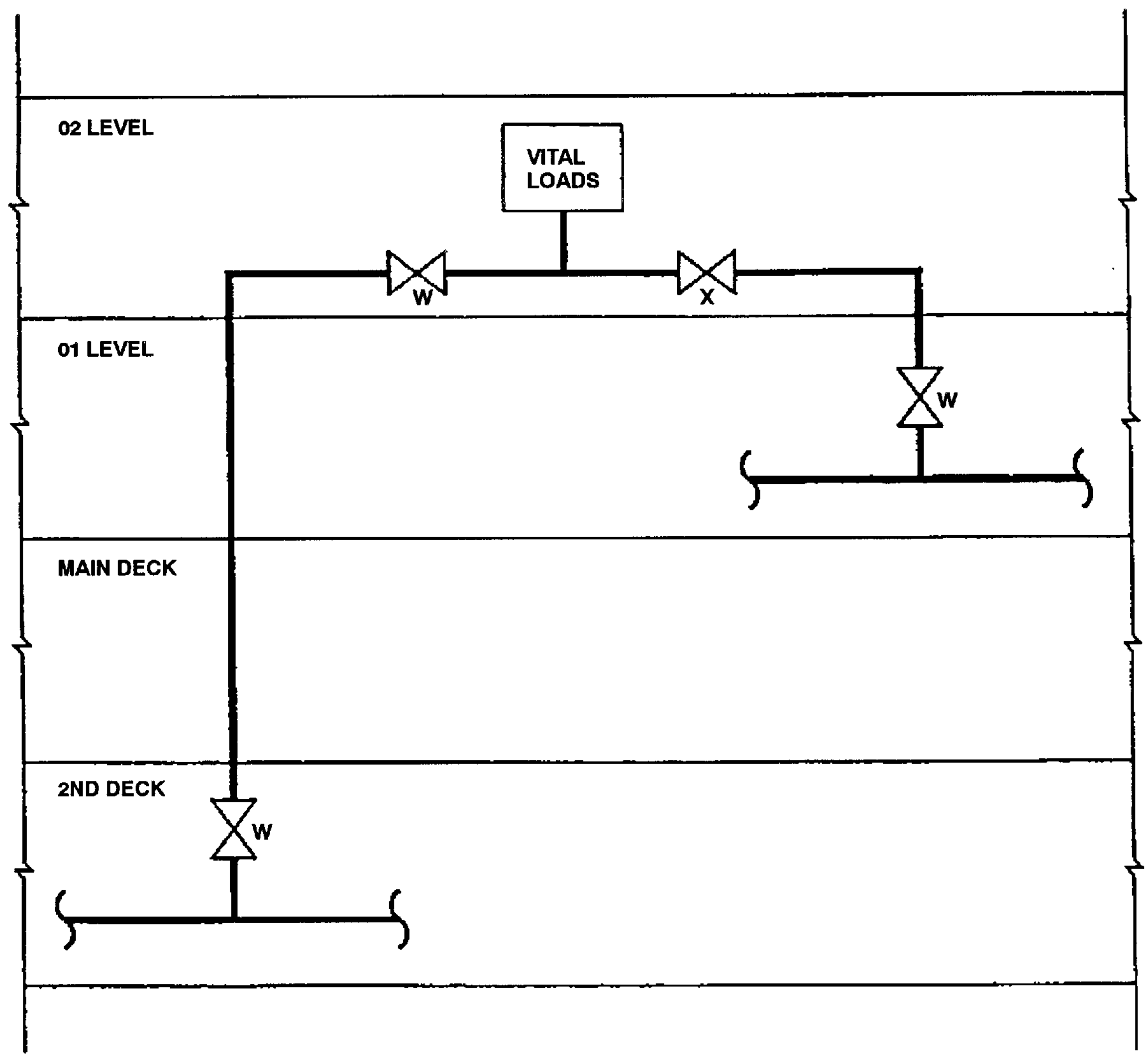


Figure 510-A-7 Vital Space Cooling Served by Single Cooling Coil or Heat Exchanger Supplying Chilled Water from Separated-Segregated Zones.

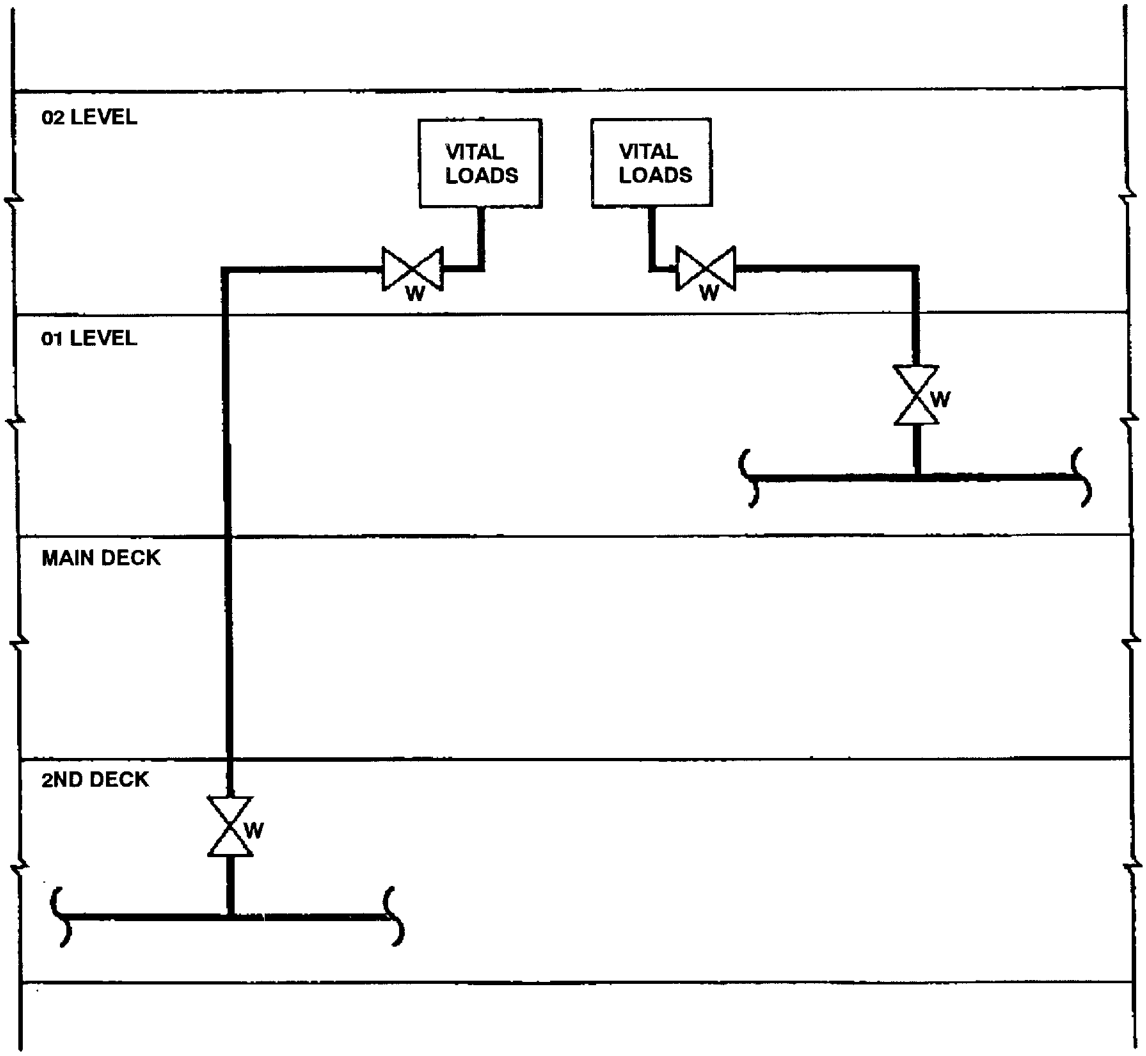


Figure 510-A-8 Vital Space Cooling Served by Single Cooling Coil or Heat Exchangers Supplying Chilled Water from Separated-Segregated Zones.

510-A.5 COMPONENTS

510-A.5.1 CIRCULATING PUMPS.

510-A.5.1.1 Description. Chilled water circulating pumps are single-stage, motor-driven centrifugal pumps that provide the head necessary to circulate chilled water in the closed loop chilled water system. The pumps are mounted horizontally and have mechanical seals to minimize system leakage and entrance of air. The pump casing has a vent to manually release air from the pump to ensure flooded suction on startup and to vent any air accumulated during operation. Figure 510-A-9 and Figure 510-A-10 show a typical chilled water circulating pump and a typical pump performance curve, respectively.

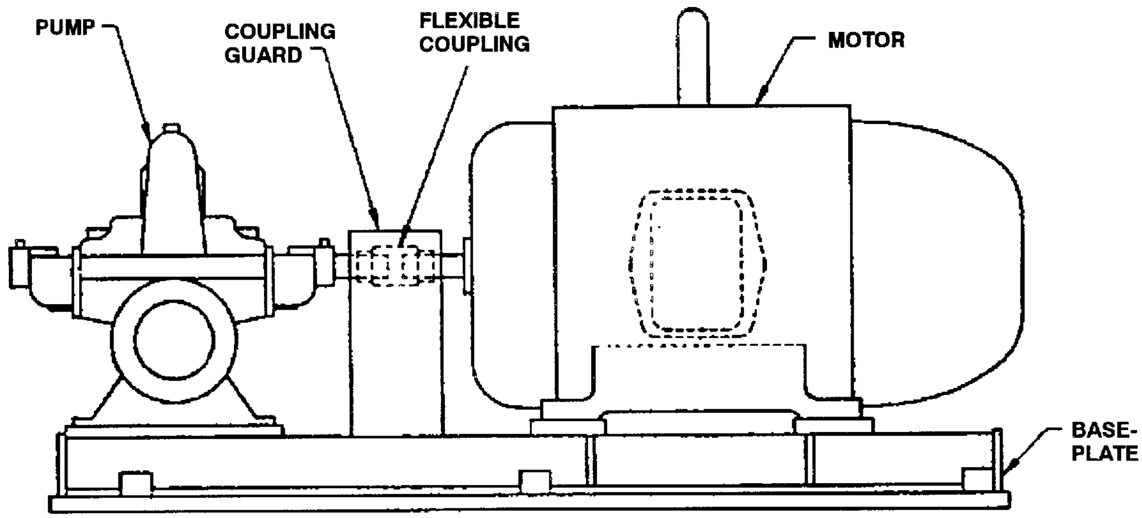


Figure 510-A-9 Chilled Water Circulating Pump.

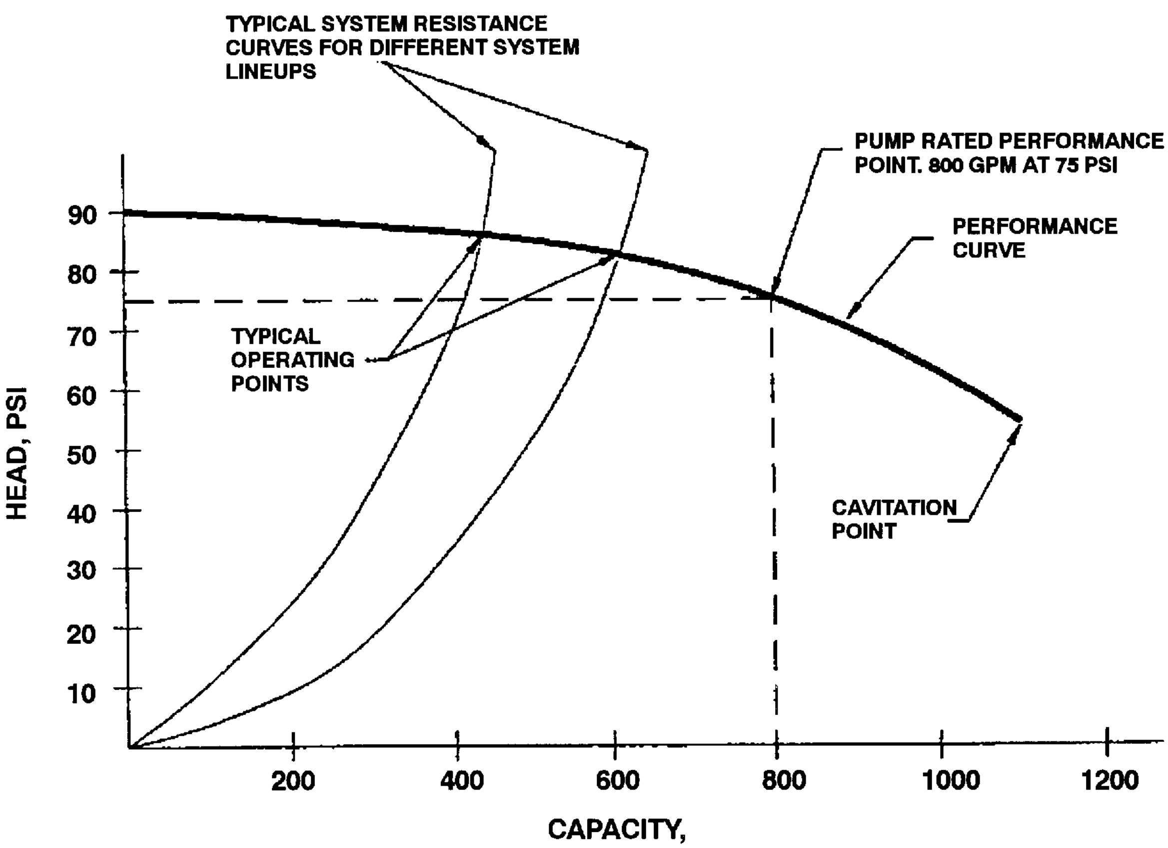


Figure 510-A-10 Typical Centrifugal Chilled Water Pump Performance Curve.

510-A.5.1.2 Sizing Criteria. Each chilled water pump is sized for the full capacity of a chilled water plant on the basis of 4.5 gpm/ton of installed air conditioning plant capacity, with a discharge head that will provide a minimum pressure of 30 pounds per square inch gauge (psig) at the highest and most remote service in each zone. The 4.5 gpm/ton value is used instead of the 3.6 gpm/ton value used in the design of cooling coils to provide a margin for load growth and to avoid starving the cooling coils farthest from the chilled water plant. One pump is typically provided for each chiller.

510-A.5.1.3 Recirculation Line Orifice. The orifice installed in the chilled water pump recirculation line is sized to protect the pump from overheating if the pump is operated with its discharge valve shut. The recirculation line routes water from the pump discharge to the chiller inlet. The pump manufacturer determines the recirculation flow requirement.

510-A.5.1.4 Recirculating Line Unloading Valve. When centrifugal or screw-type compressor refrigeration plants are installed, an unloading valve is installed in the recirculation line instead of an orifice. The valve is a soft-seated, pilot-operated, modulation-type pressure relief valve, CLA-VAL Model 50M or equal (Figure 510-A-11 and Figure 510-A-12), sized and set to maintain the minimum required flow necessary to prevent chiller shutdown during low chilled water flow. This shutdown point is determined by the AC plant manufacturer; a typical setpoint is one-third of the chiller design flow rate. The recirculation line unloading valve is sized for a flow greater than the chiller shutdown setpoint. The recirculation flow valve is selected by the chilled water system designer and is specified on the chilled water system diagram. For AC plants with a chiller shutdown setpoint of one-third of chiller design flow, the valve is set to open at a pump discharge pressure that results in a recirculation flow of approximately 40 percent of design flow. The valve unloading point is set by operating the chilled water pump with the AC plant compressor deenergized, and the pump discharge and chiller inlet isolation valves closed. The unloading valve pressure relief control adjusting screw is turned to change the relief pressure to achieve the proper flow rate through the chiller (see Figure 510-A-11). Depending on system design, the chiller flow rate is read from the AC plant control system display or at the adjacent chiller chilled water flow meter, or determined by observing the pressure drop across the chiller and consulting the chiller manufacturer's pressure drop versus flow curve. After initially adjusting the unloading valve to provide the proper flow through the chiller, no further valve adjustments should be made. Subsequently, if it is determined that the valve has not been set correctly, the AC plant manufacturer's recommended low chiller flow shutdown point and unloading valve flow requirement from the ship chilled water system diagram should be reviewed and the unloading valve adjusted to provide the required flow.

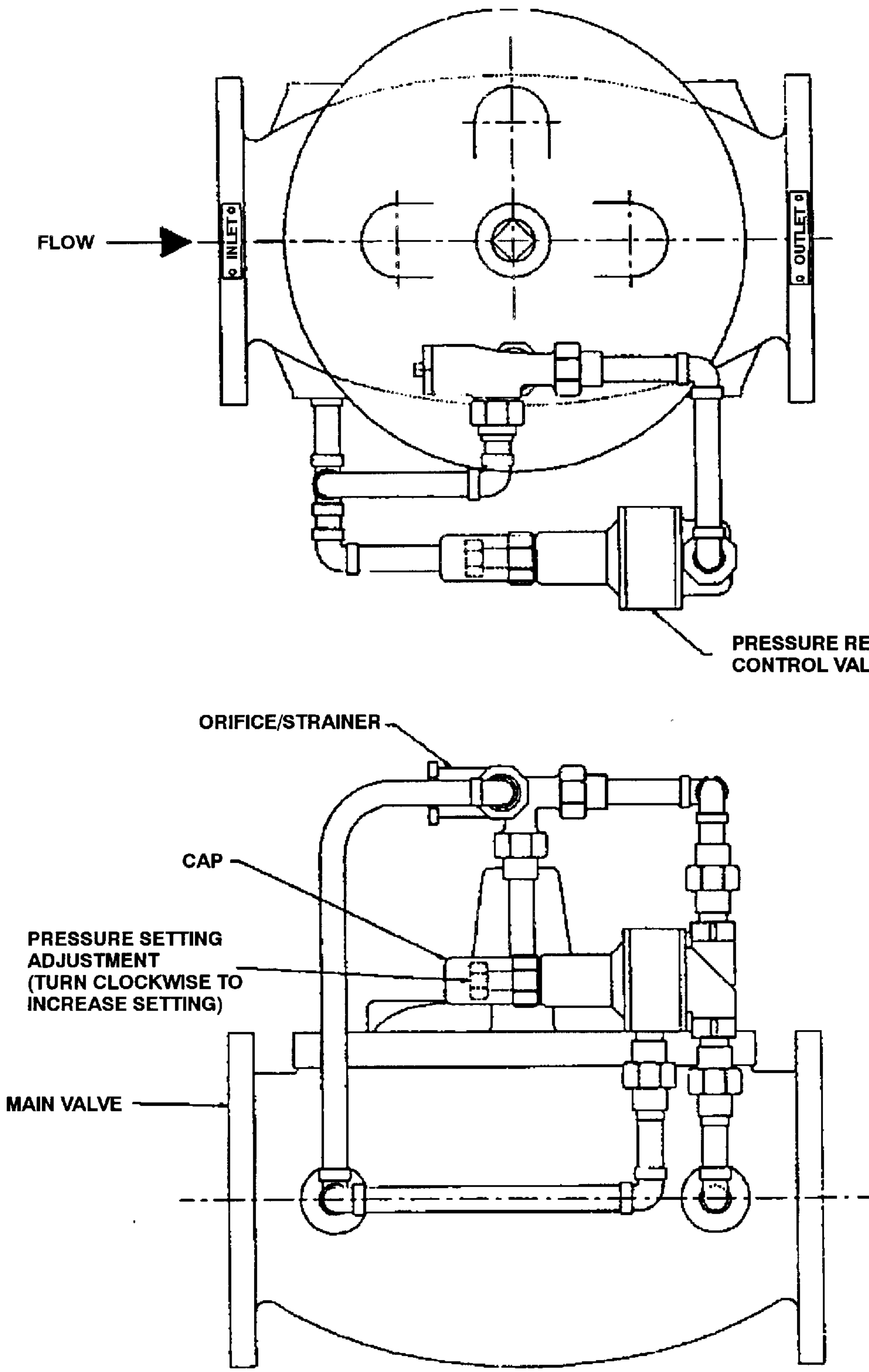
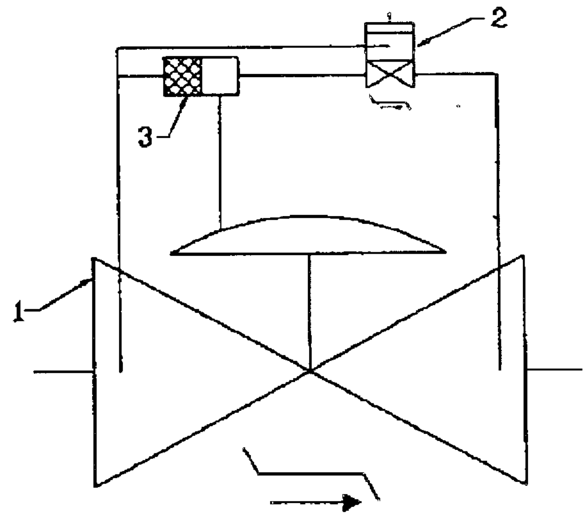


Figure 510-A-11 3-Inch CLA-VAL Model No. 50M Recirculation LIne Unloading Valve.



SCHEMATIC

OPERATING DATA

1. UPSTREAM PRESSURE ACTS ON THE DIAPHRAGM OF THE PRESSURE RELIEF CONTROL (2) AND ON THE DIAPHRAGM OF MAIN VALVE (1) THROUGH THE ORIFICE/STRAINER (3). WHEN THIS PRESSURE EXCEEDS THE SET SPRING TENSION ABOVE THE DIAPHRAGM, THE CONTROL OPENS. FLOW THROUGH THE CONTROL SYSTEM THEN REDUCES PRESSURE IN THE MAIN VALVE COVER CHAMBER. THE MAIN VALVE (1) THEN OPENS TO RELIEVE EXCESS PRESSURE.

2. AS UPSTREAM PRESSURE IS REDUCED DUE TO THE MAIN VALVE (1) OPENING, THE PRESSURE RELIEF CONTROL (2) RESPONDS TO THE REDUCTION IN PRESSURE AND CLOSES. FULL INLET PRESSURE IS THEN DIRECTED INTO THE MAIN VALVE COVER CHAMBER. THE MAIN VALVE (1) CLOSES.

Figure 510-A-12 3-Inch CLA-VAL Model No. 50M Recirculation LIne Unloading Valve Schematic.

510-A.5.2 EXPANSION TANK.

510-A.5.2.1 Description. The expansion tank compensates for volumetric changes in the chilled water loop, maintains a positive head on the system, collects air entrained in the chilled water, and provides a source of makeup water to replace system leakage. The expansion tank also serves as a surge tank that allows room for the dissipation of system pressure transients which may occur during zone resegregation as the chilled water pumps stabilize at new operating points. It is pressurized with compressed air from the ship service air system to maintain a minimum pressure of 5 psig at the chilled water pump inlet under all operating conditions. The tank material is usually 90:10 copper-nickel alloy.

510-A.5.2.2 Sizing Criteria. Each chilled water expansion tank is sized for a water capacity equal to the 30-second pumping capacity of the chiller chilled water pump for combatants, and the 10-second pumping capacity for noncombatants. In addition, the expansion tank is sized to ensure that the air volume above the working liquid level in the tank is large enough to accommodate the increase in the volume of the chilled water system for a system temperature rise from 32° to 120°F.

510-A.5.2.3 Expansion Tank Auxiliaries. Each expansion tank has a vacuum relief valve, pressure relief valve, air charging connection, vent, drain, and fill connections. The vacuum relief valve lets water flow freely from the tank to the pump suction header should a partial vacuum occur in the expansion tank. The vent allows for air displacement during filling or draining of the expansion tank. Paragraph 510-A.7.7 describes the expansion tank instrumentation and controls.

510-A.5.3 CHILLER.

510-A.5.3.1 Description. The water chiller is a shell-and-tube heat exchanger that reduces the circulating water temperature to 44°F for distribution to chilled water services. The chiller is usually a two-pass unit with copper tubes. It is an integral component of the AC plant, which also includes the refrigerant compressor, condenser, and controls. In a reciprocating compressor chilled water plant, the chiller is designed to operate with refrigerant flow through the tubes and water flow through the shell (called a direct expansion cooler). In a centrifugal plant unit, water flows through the tubes and refrigerant flows through the shell (called a flooded cooler). The direct expansion cooler is inherently a safer design than the flooded cooler design. This is because of the potential for ice to form in the chilled water if the AC plant low chilled water temperature cutout switch fails. In the event of ice formation, ice would collect on the outside of the tubes in the direct expansion design, causing no damage to the chiller. But in the flooded cooler design, ice would form inside the tubes and possibly rupture them. Reciprocating compressor AC plants are high-pressure systems that can operate successfully with the high refrigerant pressure drop in the refrigerant expansion valve that feeds the chiller. AC plant centrifugal compressors, however, are high volume (high AC plant tonnage) low head machines that operate best with a minimal refrigerant pressure drop across the chiller. Thus, the flooded chiller design, with its low refrigerant pressure drop across the chiller tube bank, is chosen for centrifugal compressor AC plants. Figure 510-A-13 shows a typical centrifugal air conditioning plant; the chiller is the lower heat exchanger, while the condenser is on top. Figure 510-A-14 shows a typical reciprocating air conditioning plant.

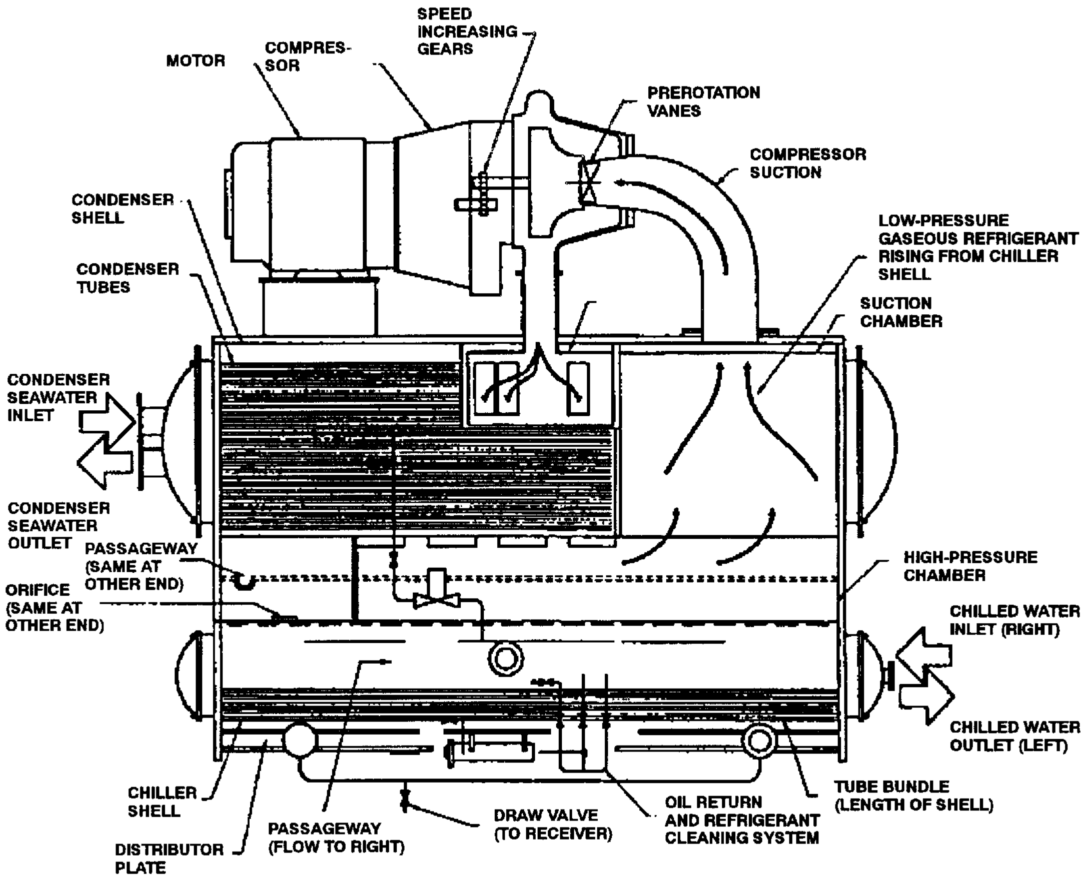


Figure 510-A-13 Typical Centrifugal Air-Conditioning Plant.

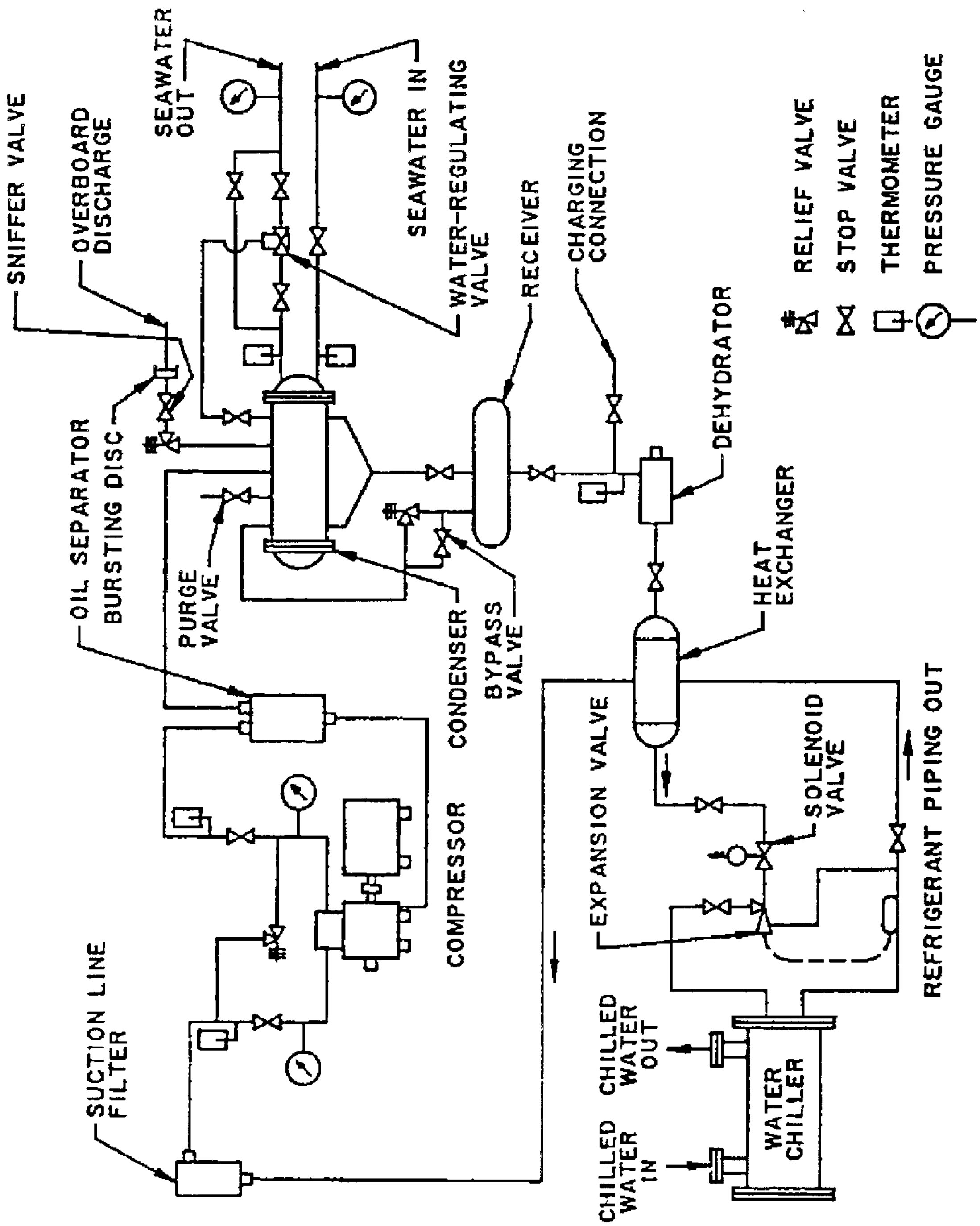


Figure 510-A-14 Reciprocating Air-Conditioning Plant Schematic.

510-A.5.3.2 Sizing Criteria. The size of the chiller is chosen to be consistent with the size of the chilled water plant. The chilled water plant load is determined from the sum of the ship air conditioning load; electronic cooling water system demand; and loads for sample water coolers, drinking fountain coolers, dehydrators, and other minor services.

510-A.5.4 PIPING AND VALVES.

510-A.5.4.1 Description. Chilled water piping material may be copper, 90:10 copper-nickel, or glass-reinforced plastic. Copper is the most common material for piping branches of less than 3 inches nominal diameter; 90:10 copper-nickel is a common material for piping over 3 inches nominal diameter and is typically used for mains and risers. Chilled water piping serving air conditioning cooling coils classified WILLIAM, and the portion of the system serving the electronics cooling water system, is fabricated of 90:10 copper-nickel pipe and fittings, with welded joints wherever possible. The use of glass-reinforced plastic is limited to nonvital services. Gate, globe, butterfly, and ball valves may be used in the chilled water system. The valve type is determined by space, weight, cost, and application considerations. Solenoid valves controlled by conditioned space thermostats open and close to admit chilled water to the HVAC cooling coils. Expansion tank compressed air valves are soft-seated.

510-A.5.4.2 Piping Sizing Criteria. The size of the chilled water system piping is chosen to provide minimum pressure drop and maximum flow capacity. Maximum allowable water velocity is 12 feet per second (fps) in the mains, cross-connections, and risers; and 9 fps in the branches, as required by the U.S. Navy General Specifications for Ships. With the zone segregation valves in the mains open, the chilled water plants are cross-connected, and the pressure in the mains tends to equalize among the pressures supplied by each zone chilled water plant. Thus the mains act as a relatively constant pressure source for the chilled water users, serving to minimize flow disruptions to the cooling coils and heat exchangers as they randomly come on and off line.

510-A.5.5 AUTOMATIC AIR VENTS. At least one automatic air vent is installed in each chilled water zone at the highest branch in the zone. The vents remove air from the chilled water system piping; the air tends to rise to the highest points in the zone. If cooling coils are located at these points and the air is not removed, the air can collect in dead spots in the cooling coil tubing, inhibiting heat transfer in the coils. The vents consist of a root cutout valve, automatic vent valve, return bend, funnel, and drain.

510-A.6 CHILLED WATER SERVICES

510-A.6.1 HVAC COOLING COILS. Chilled water is supplied to air conditioning system cooling coils, which cool and dehumidify the HVAC system ventilation air. These coils are crossflow heat exchangers with chilled water flowing through finned tubes and air flowing over the tubes. The cooling coils are integrated into various assemblies depending on the application in the ship HVAC system. The correct amount of chilled water is delivered to a cooling coil through a constant-flow regulating fitting normally located in a straight section of the pipe supplying the coil. The Hayes Measurflo constant flow fitting is the product usually selected for cooling coil chilled water flow control; it is described in paragraph 510-A.7.9. Each cooling coil load, and thus each constant-flow regulating fitting, is usually sized for 3.6 gpm/ton. Chilled water is admitted to cooling coils via a solenoid control valve operated by a switch on the associated space thermostat. A typical cooling coil chilled water piping arrangement is shown in Figure 510-A-15.

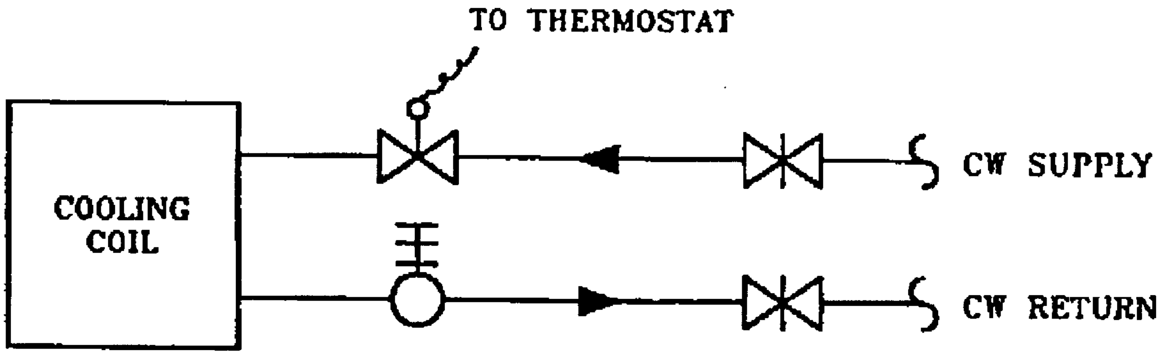


Figure 510-A-15 Cooling Coil Chilled Water Piping.

510-A.6.2 ELECTRONIC COOLING WATER. Electronic cooling water system heat exchangers are supplied chilled water for cooling. The electronic cooling water system is described in **NSTM Chapter 532, Liquid Cooling Systems for Electronic Equipment.** The heat exchangers are supplied chilled water via a temperature-regulating valve and a venturi flow meter. A constant-flow regulating fitting is installed in the chilled water return line.

510-A.6.3 AEGIS ANTENNA ARRAYS. Chilled water is supplied to the SPY-1 radar arrays on AEGIS equipped ships. A pressure switch and gauge are installed in the supply branch to each array. The pressure switch is set to actuate a visual and audio alarm whenever the pressure in the branch drops to a predetermined level. All four arrays are supplied with chilled water from the same zone. In addition, both the forward and aft pairs of arrays have a cross-connection to a separate segregated zone. The backup chilled water branch is provided with an X-RAY valve.

510-A.6.4 STEERING GEAR HYDRAULIC OIL COOLERS. Chilled water is provided to steering gear hydraulic oil coolers to reduce the oil temperature. These coolers typically are shell and tube heat exchangers.

510-A.6.5 SAMPLE WATER COOLERS. Chilled water may be provided for a variety of sample cooler applications, including sample coolers for boiler water, desuperheater leak testing, and deaerating feed tank dissolved oxygen water. The chilled water flow requirement varies with the application and is specified by the sample cooler manufacturer.

510-A.6.6 MISCELLANEOUS SERVICES. Chilled water is supplied to various equipment requiring cooling water at a temperature below 90°F. This equipment includes compressed air dehydrators, photo-lab cooling systems, 400-hertz power supplies, and drinking fountain coolers.

510-A.7 INSTRUMENTATION & CONTROL

510-A.7.1 AIR-CONDITIONING PLANT ALARMS. Ship AC plants include status indicators and alarms to warn the operator of abnormal plant conditions. Generally, the newer-design AC plants and most recently-built ships are equipped with the most extensive AC plant local and remote monitoring. Local alarms are provided on the AC plant operating panel, while remote alarm panels are placed in the Engineering Operating Stations (EOS) or on the auxiliary control console (ACC) in the central control station (CCS). Both local and remote AC plant summary fault alarms usually are installed. These alarms sound during the following AC plant conditions: high compressor oil temperature, low compressor oil pressure, high refrigerant pressure, low refrigerant temperature, and high compressor motor temperature. The AC plant summary fault alarm also sounds during the abnormal chilled water system conditions of low chilled water pump discharge pressure, high chiller discharge temperature, low chiller discharge temperature, low chiller chilled water flow, low condenser seawater flow, and low chilled water expansion tank level. Interlocks are provided to shut down the AC plant as well as sound alarms under AC and CW plant conditions that are critical for AC plant operation without AC plant component damage. These AC and CW conditions are: low-low compressor oil pressure, low-low chiller outlet temperature, low chiller chilled water flow, low condenser seawater flow, and low-low chilled water expansion tank level.

510-A.7.2 CHILLED WATER THERMOSTAT (CHILLED WATER TEMPERATURE CONTROL SWITCH). The chilled water thermostat, mounted on the local AC plant operating panel, maintains the temperature of the water discharged from the chiller at 44°F by regulating the flow of refrigerant in the air conditioning plant. In a reciprocating compressor plant the thermostat senses chilled water temperature via a sensing bulb located in the chiller shell. The thermostat makes and breaks the electrical circuit to a solenoid-operated refrigerant isolation valve located in the liquid refrigerant line to the expansion valve. In a centrifugal compressor plant the thermostat senses the water temperature in the chilled water outlet piping, sending a signal to the compressor prerotation vanes pilot positioner, and alters plant capacity to maintain the thermostat setpoint temperature.

510-A.7.3 LOW CHILLED WATER TEMPERATURE CHILLER SHUTDOWN SWITCH. The low chilled water temperature chiller shutdown switch is a safety device that stops the compressor if the chilled water temperature drops to the minimum permissible level. Thus, this switch prevents a freeze-up in the chiller. The thermal bulb for the low temperature switch is located in the water chiller shell for reciprocating compressor plants and in the chilled water outlet piping for centrifugal compressor plants. If the compressor is stopped by this switch, it must be restarted manually after the chilled water temperature rises to the setting of the low chilled water temperature cut-in switch. Typical switch settings for a design chilled water temperature of 44°F are 35° to 37°F for the low temperature cutout setting and 41° to 43°F for the low temperature cut-in setting.

510-A.7.4 CHILLED WATER TEMPERATURE ALARMS. Temperature switches in the chiller chilled water discharge piping monitor the chilled water outlet temperature, and alarms sound at the ACC in the CCS if temperature limits are exceeded. For a typical chilled water plant, a low temperature alarm is activated when the chilled water temperature falls below 35°F, while a high temperature alarm is activated when the chilled water temperature exceeds 46°F.

510-A.7.5 CHILLED WATER TEMPERATURE INDICATORS. Local thermometers are installed at the inlet and outlet of each chiller. On combatants, remote-reading temperature sensors are located in the return line to and the supply line from each chilled water plant. The remote-reading temperature indicators are located near the chilled water flow meter readouts. A chart is provided that allows determination of the chiller tonnage from the chilled water flow value and the temperature drop of the chilled water across the chiller.

510-A.7.6 CHILLED WATER FLOW METERS. Venturi meters or elbow flow meters with permanently mounted differential pressure indicators are installed on each plant. They are located in the discharge line from the chilled water pump on single plants (Figure 510-A-2) and at the exit from each chiller on a chilled water plant with multiple chillers and pumps (Figure 510-A-4). The meters normally have a measurement range from 30 to 120 percent of the design chilled water flow rate. On recently designed combatants such as LHD 1, flanged vortex shedding flow meters with digital readout are installed in lieu of venturi or elbow meters. These meters normally have a measurement range from 10 to 120 percent of the design chilled water flow rate. The meter readout is local at the chilled water plant and remote at a continuously manned watchstation.

510-A.7.7 EXPANSION TANK INSTRUMENTATION and CONTROL. Each chilled water expansion tank has a pressure relief valve, vacuum relief valve, pressure gauge, compressed air charging orifice, liquid level indicator (sight glass), vent, drain, and fresh water fill connection. Recent chilled water system designs also have one or more liquid level sensors that sound an alarm when the tank water level drops to a predetermined setpoint level, such as a 25-second reserve capacity for combatants and a 5-second reserve capacity for noncombatants. The 25-second capacity refers to the volume of water that would be discharged from the tank if the chilled water pump operates for 25 seconds at its rated flow. Another sensor shuts down its respective chilled water pump when the level is at the 10-second reserve capacity for combatants and zero reserve capacity for noncombatants. The reason for pump shutdown before the tank is emptied is to prevent air from being ingested into the chilled water system, which could cause pump damage and airbound cooling coils and heat exchangers. The expansion tank alarms sound locally and at the ACC of the CCS for combatants and at the EOS for noncombatants.

510-A.7.8 DISTRIBUTION ZONE MONITORS. A monitoring system consisting of a thermometer, high temperature switch, pressure gauge, low-pressure switch, 5-gpm Measurflo constant flow fitting, and low flow switch is installed at the most remote vital load in each chilled water zone. Figure 510-A-16 shows a typical zone monitoring system. The monitoring system actuates a visual and audio alarm whenever the chilled water temperature exceeds 48°F, the flow is less than 4.5 gpm, or the pressure drops below 25 psig. The alarms are normally located in damage control central or the CCS. If any of these alarms are actuated, the operator is alerted that equipment failure or reduced heat transfer may occur in the vital heat exchangers of that zone.

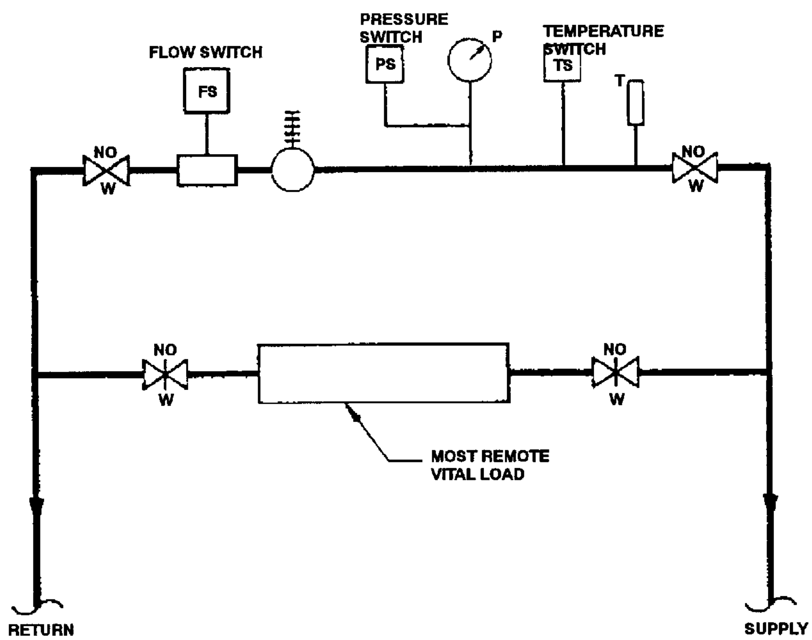


Figure 510-A-16 Typical Zone Alarm Arrangement.

510-A.7.9 CONSTANT FLOW FITTINGS. The Hayes Measurflo flow control and balancing valve is a constant flow fitting used to provide the required chilled water flow to a cooling coil or heat exchanger. Figure 510-A-17 shows a typical fitting. The principle of operation of the fitting is based on the proportioning of flow between a resilient diaphragm and an orifice plate. The diaphragm and orifice plate are located and sized to provide the design flow rate at a minimum 15-pounds-per-square-inch (psi) differential pressure with no deformation of the diaphragm. As the differential pressure increases, however, the diaphragm deforms to restrict the passage in the orifice plate, and thus maintains constant flow.

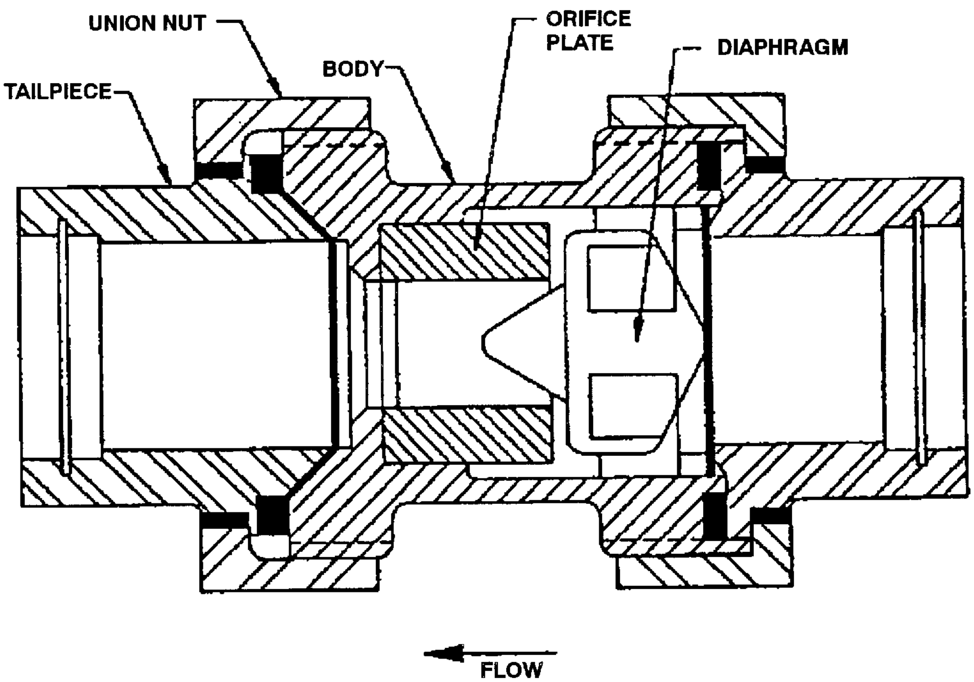


Figure 510-A-17 Constant Flow Fitting.

510-A.7.10 SPACE THERMOSTAT and COOLING COIL SOLENOID VALVE. An HVAC system thermostat installed in the conditioned space controls the ambient temperature for the majority of shipboard spaces. The thermostat controls the cooling of the air going through the HVAC cooling coils. It does this by activating an internal switch which opens and closes a solenoid-operated control valve located in the chilled water piping supplying the cooling coil. The switch setting is adjusted at the thermostat.

510-A.7.11 CHILLER FRESH WATER FAILURE SWITCH. A pressure switch installed in the chiller inlet piping stops the chilled water plant compressor when the inlet water pressure drops below a predetermined level. A typical switch setpoint level is 30 psig.

510-A.7.12 CHILLED WATER PUMP LOW-PRESSURE ALARM. A pressure switch installed in each chilled water pump discharge line actuates an alarm in the CCS when the discharge pressure drops below a predetermined level. Typical switch setpoints range from 40 to 70 psig.

510-A.8 OPERATION

510-A.8.1 SAFETY PRECAUTIONS. Personnel operating AC plant and chilled water system components must comply with the following safety precautions:

a. Treat fluorocarbon refrigerants and solvents as toxic gases. Prior to entering a space containing or suspected of containing a concentration of refrigerant vapor, the space shall be certified gas-free, or the person(s) entering shall wear a self-contained oxygen breathing apparatus.

b. Refrigerants, either in the liquid or vapor phase, are nonflammable and nonexplosive, and air mixtures of these refrigerants are incapable of propagating a flame. Refrigerant vapors can decompose, however, to phosgene, acid vapors, and other products when exposed to an open flame or hot surface. Do not smoke, braze, or weld when refrigerant vapors are present.

c. Depressurize and evacuate chilled water system components in accordance with the equipment technical manual prior to performing corrective maintenance.

d. Prior to working on the chilled water system or its components, ensure that all required isolation valves have been shut and tagged, DO NOT OPEN.

e. Do not start the air conditioning plant before water is circulated through the chilled water loop and the chiller. Failure to do so may result in water freezing inside the chiller tubes and subsequent tube damage.

f. Stop the air conditioning plant before securing the chilled water pump flow through the plant.

g. Do not operate the chilled water pump unless the pump suction is flooded with water.

h. Prior to working on electrical equipment, place all switches and circuit breakers in the open (off) position and tag DANGER, SHOCK HAZARD. DO NOT CHANGE POSITION OF SWITCH EXCEPT BY DIRECTION OF NAME...RATE/RANK.

i. If the chilled water pump rotor is bound and will not rotate, do not start the pump until the cause of the binding is corrected.

j. In case of severe chilled water pump vibration or unusual noise, stop the pump and determine the cause of the vibration or noise.

k. Do not attempt to wipe down rotating machinery while the machinery is energized.

l. When cleaning equipment, use only approved cleaning solvents with adequate compartment ventilation. The use of solvents containing chlorofluorocarbons (CFC’s), such as R-113, and carbon tetrachloride is prohibited.

510-A.8.2 INITIAL CONDITIONS. Before operating the chilled water system and associated AC plant components, do the following:

1. Check the lubrication of the AC plant compressor motor and all auxiliary motors.
2. Ensure AC plant compressor oil level is adequate.
3. Ensure that the AC plant compressor oil sump temperature is maintained at 135°F or higher for at least one hour before compressor startup.
4. Ensure that the AC plant refrigerating system has been properly charged with refrigerant.
5. Open the AC plant condenser seawater cooling isolation valves and the chiller chilled water isolation valves, and fill the condenser and chiller with coolant. Vent air from the condenser and the chiller through the condenser and chiller vent valves.
6. Ensure the chilled water pumps and seawater pumps have been lubricated in accordance with the pump technical manuals. The condenser cooling water may be supplied from the auxiliary seawater system on some ships rather than from dedicated seawater pumps.
7. Before starting a chilled water pump, rotate the pump shaft by hand to ensure freedom of rotation. There should be no rubbing or binding.
8. Before starting a chilled water pump, energize the pump momentarily. Verify that the pump shaft rotation is in the correct direction as viewed from the motor end (clockwise or counterclockwise) per the pump technical manual.

9. Before starting a chilled water pump, ensure that the plant chilled water expansion tank is filled and pressurized and that the expansion tank cutout valve is open.

510-A.8.3 CHILLED WATER PUMP STARTUP. Start the chilled water pumps using the following procedure:

1. Check that the rotor turns freely by turning the rotor by hand. To turn the rotor by hand, remove the coupling guard and rotate the coupling several times.

CAUTION

If the rotor is bound, do not start the pump until the cause of the binding is corrected.

2. Open the pump suction valve.
3. Vent the pump by opening the vent valve at the highest point of the pump casing to release all entrapped air. Close the vent valve when a constant flow of water emerges from the valve.

CAUTION

Do not operate the pump without water in the casing.

4. Start the pump motor according to the directions on the controller. Check that the pump is rotating in the correct direction as viewed from the motor end (clockwise or counterclockwise) per the pump technical manual.

CAUTION

In case of severe vibration or unusual noise, stop the pump motor at once and determine the cause.

5. Open the pump discharge valve slowly.

510-A.8.4 CHILLED WATER PUMP SHUTDOWN. Stop the chilled water pump as follows:

1. Close the pump discharge valve.
2. Stop the pump motor according to the controller manufacturer's instructions.
3. Close the pump suction valve.

510-A.8.5 CHILLER OPERATION. Chiller operating instructions are contained in **NSTM Chapter 516** and in the individual air conditioning plant technical manuals. Study these manuals thoroughly before operating the AC plant and chiller.

510-A.8.6 CHILLED WATER SUPPLY TO ADJACENT CHILLED WATER PLANT. Chilled water plants that are installed in pairs in a machinery room may be cross-connected to allow the chiller of one plant to accommodate the cooling load normally associated with the adjacent plant, if that plant is unavailable. Zone nonvital cooling loads may need to be secured prior to this operation to prevent the operating plant from being overloaded by the additional demand. The following steps shall be taken to supply chilled water to an adjacent chilled water plant when its refrigerating unit has been secured:

1. Close the chiller inlet and outlet isolation valves of the secured chilled water plant.
2. Open the valves in the chilled water plant chilled water return, supply, and chilled water pump suction cross-connections.
3. Operate the system with the chilled water pumps of each plant running; ensure that the chilled water pumps operate without excessive noise or vibration.

510-A.8.7 CHILLED WATER EXPANSION TANK.

510-A.8.7.1 Adding Compressed Air. If the water level in the expansion tank is at the proper level but the pressure in the tank is low, the tank should be charged with compressed air as follows:

1. Connect an air charging hose from the ship service compressed air system to the expansion tank air-charging valve. Keep the compressed air system isolation valve closed.
2. Open the tank air charging valve. Slowly open the compressed air system isolation valve, admitting compressed air to the tank.
3. When the expansion tank pressure gauge indicates the proper air pressure as stated in the individual Ship Information Book or chilled water system diagram, close the compressed air isolation valve.
4. Close the expansion tank air charging valve, open the charging connection vent valve, and detach the air charging hose. Close the charging connection vent valve.

510-A.8.7.2 Adding Water. Raise the expansion tank water level by adding water to the tank as follows:

1. Open the expansion tank vent valve. Attach a hose from the fresh water system to the fresh water fill hose connection on the expansion tank.
2. Open the expansion tank fill connection isolation valve and the fresh water system isolation valve to start water flow into the expansion tank. Raise the tank water level until the proper level shows in the tank gauge glass. Close tank vent valve.
3. Pressurize the expansion tank with compressed air to the proper pressure.

510-A.8.7.3 Draining Expansion Tank. The expansion tank may be drained as follows:

1. Close expansion tank and return riser isolation valve.
2. Attach a drain hose to the tank drain hose connection. Run the hose into a funnel to the plumbing gravity drain system.
3. Open the expansion tank vent valve and the expansion tank drain valve; drain down the expansion tank to the desired level.
4. Recharge tank with compressed air to desired operating pressure.

510-A.8.8 CHILLED WATER SYSTEM VENTING. Air may be introduced into the chilled water system through the expansion tank or at the chilled water pump after equipment maintenance. This air, if not removed from the system, will migrate to the highest elevation points of the system. The air may then collect in cooling coil and heat exchanger tubes and blanket the heat transfer surfaces, inhibiting heat transfer. Automatic air vent valves are installed in modern chilled water systems to remove entrained air. Manual vents are also included in chilled water systems at the HVAC cooling coils, chilled water cooled heat exchangers, chilled water pump casings, chiller heads, and other areas where air may collect. After the system has been opened for equipment maintenance, the system manual vents should be opened, starting with the lowest elevation vent and advancing to higher elevation vents, until all entrained air in the piping is removed. At each manual vent, the vent valve should be opened until a clear stream of water emerges. Adding water to the chilled water system may be necessary after venting is completed.

510-A.8.9 EMERGENCY OPERATION.

510-A.8.9.1 Fault Alarms. AC plant and chilled water system alarms are located on a fault alarm panel in either the EOS or the CCS. Some ships are also equipped with chilled water system zone alarms, one per chilled water zone, which also sound at the EOS or CCS when low chilled water flow, low chilled water pressure, or high chilled water temperature are detected in a chilled water zone. When one of these alarms is activated, the station operator acknowledges the alarm and dispatches a technician to the AC plant, chilled water plant, or zone alarm location (the vital cooling coil farthest from the zone chilled water plant), as necessary, to determine the cause of the alarm.

510-A.8.9.2 Piping Failure. The failure of chilled water system piping is a catastrophic failure that would cause a rapid loss in system pressure at the piping break point. If the system is segregated (zone isolation valves closed) at the time of the casualty, a low-pressure zone alarm will sound, and the expansion tank level will drop in proportion to the size of the pipe break. In modern chilled water systems on combatants, approximately 30 seconds of system operation is possible with a chilled water loss comparable to the chilled water pump flow rate. At this point the expansion tank low-low level alarm and chilled water pump interlock would stop the zone chilled water pump and AC plant. If the system is not segregated into zones during the casualty, the entire system pressure will drop and all expansion tank levels will decrease; additional operation time would be gained due to the available water inventory of all the expansion tanks. System operation during such a failure may be maintained by dispatching a damage control party to isolate the damaged area of piping and route chilled water through alternate paths to the affected vital loads.

510-A.8.9.3 Air Conditioning Plant Failure. Failure of an AC plant will be accompanied by one or more AC plant or CW plant alarms; in many recently-designed AC plants, protective interlocks will disable the plant and prohibit operation until the cause of the failure is corrected. Troubleshooting procedures in paragraph 510-A.10 and the AC plant technical manual should be followed to determine the reason for the failure. Normal system operation is usually possible in modern chilled water systems with one AC plant inoperable; in this case the vital loads normally supplied by the disabled AC plant may be supplied by an alternate section of the mains or by an alternate branch. Nonvital loads may be supplied by an alternate section of the mains. If the design chilled water temperature cannot be maintained with a disabled AC plant, the nonvital (ZEBRA) loads should be selectively secured until the remaining operating AC plants can satisfy the ship load.

510-A.8.9.4 Chilled Water Pump Failure. Failure of a chilled water pump will normally require securing its associated AC plant and will result in the same consequences as described in the preceding paragraph. If the AC plants are installed in a dual-plant configuration, however, as shown in Figure 510-A-3 or Figure 510-A-4, it may be possible to operate the system using the remaining operating CW pump to provide flow through each chiller. If this operating mode is attempted, the chilled water system should be segregated into zones, and the nonvital loads in the affected zones should be secured.

510-A.9 MAINTENANCE AND REPAIR

510-A.9.1 MAINTENANCE APPROACH. Maintenance performed on the chilled water system falls into two broad categories: planned maintenance and corrective maintenance. Planned maintenance is action taken to reduce or eliminate failures and prolong the useful life of the equipment. Corrective maintenance is action taken when a part or component has failed and the equipment is out of service. Planned maintenance is generally performed on board ship, while corrective maintenance may be performed on board or off board ship. To keep the chilled water system in reliable operating condition, it is necessary to follow the planned procedure of periodic inspections and adjustments. Detailed repair procedures are listed in the applicable equipment technical manuals and the Planned Maintenance System (PMS). The PMS should be consulted prior to proceeding with any repair work on the system. The maintenance instructions in this chapter are not intended to duplicate those furnished in the PMS and the equipment technical manuals, but are intended for use where PMS procedures do not exist or do not apply. They also provide general maintenance guidance applicable to each general category of components. Where appropriate PMS procedures do exist for the equipment in question, they should be followed. The PMS procedures are indexed on Maintenance Index Pages (MIP’s) and detailed on Maintenance Requirement Cards (MRC’s).

510-A.9.1.1 MIP’s and MRC’s. A MIP lists all applicable MRC’s for each item of equipment. MRC’s provide the detailed procedures for performing the planned maintenance and reference the applicable equipment technical manual. MRC’s provide detailed maintenance instructions; repair rates; required man-hours; and required tools, parts, materials, and test equipment.

510-A.9.2 CHILLER MAINTENANCE.

510-A.9.2.1 Tube Leaks. To avoid refrigerant loss through leaking tubes and contamination of the refrigerant by chilled water, the chiller should be checked periodically for tube leaks. The best time for testing is just before starting the AC plant after an overnight shutdown; the refrigerant pressure in the chiller and condenser shells will have stabilized at the refrigerant saturation pressure at the plant ambient temperature. For example, for an R-114 plant at 80°F, the refrigerant pressure would be approximately 18 psig after pressures have stabilized. With the chiller heads isolated from the chilled water system pressure and the heads vented to atmosphere, refrigerant will leak from the chiller shell to the chilled water head if any of the chiller tubes are leaking. The refrigerant may be detected in the chiller head with a refrigerant leak detector. With the chiller chilled water isolation valves closed, slowly open the chiller head vent valves, one at a time, to vent the heads of chilled water pressure. Insert the detection probe of a refrigerant leak detector into the head vent and the air pocket at the top of the chiller head to test for the presence of refrigerant. The air pocket forms after the AC plant has been secured. If no refrigerant can be detected, remove the probe, wait approximately 30 minutes, and reinsert the probe again to test for refrigerant. If refrigerant is still not detected, there are no chiller tube leaks. If refrigerant is detected, the leaking tube(s) must be found and plugged or replaced. Follow the AC plant technical manual instructions and PMS procedures for determining which tubes are leaking. A typical procedure for identifying the leaking tube(s) is as follows:

1. With the chiller chilled water isolation valves closed and the head vented, remove the chiller head.
2. Clean the tubesheet and tube ends with water; dry out the tubes by blowing them out with dry nitrogen.

3. Drive corks into the ends of the suspected leaking tubes; if necessary, cork all tubes. Allow the tubes to remain plugged for 12 hours.
4. Starting with suspected leaking tubes, remove the cork from each tube, and insert the refrigerant leak detector probe for five seconds. If refrigerant is detected, mark the tube for plugging or replacement.

510-A.9.2.2 Tube Plugging and Replacement. If a chiller tube is leaking and it is impractical to immediately replace the tube, the leaking tube may be plugged. Tubes are usually plugged with copper or brass plugs that are soldered into the end of the leaking tube (Figure 510-A-18). The procedure is as follows:

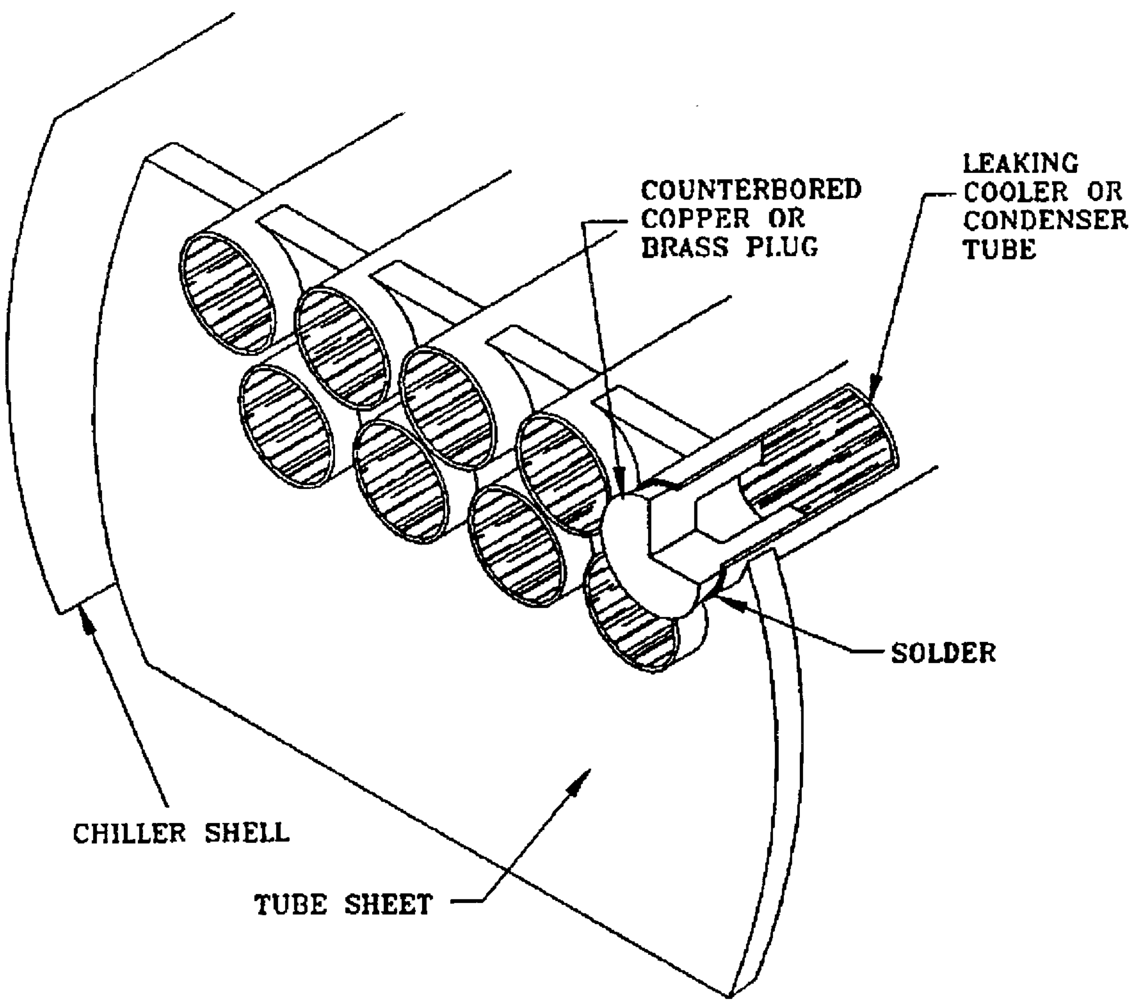


Figure 510-A-18 Plugging Leaking Chiller Tubes.

1. Prepare the required number of copper or brass plugs. The outside diameter of each plug should be slightly less than the inside diameter of the tube so that the plug enters the tube with a sliding fit. Counterbore the plug so that the wall thicknesses of the plug and tube are approximately equal to facilitate soldering.
2. Polish the inside surfaces of both ends of the leaking tube and the outside surfaces of the plugs. Apply a light coat of flux to both surfaces.
3. Insert a plug in each end of the leaking tube and solder the joint between the plug and tube with 95:5 soft solder.

4. Replace the plugged tube as soon as the system can be shut down. Plugging tubes is not a permanent repair. Follow AC plant technical manual and PMS procedures to replace the tubes.

510-A.9.3 CHILLED WATER PUMP PREVENTIVE MAINTENANCE. The following maintenance actions are typical shipboard chilled water pump PMS items. In case of conflicts, the ship PMS procedures take precedence.

510-A.9.3.1 Operation of Idle Pumps. If a chilled water pump has not been operated in the past seven days, run the pump for 15 minutes. If power is not available, remove the coupling guard and turn the rotor by hand for several turns by rotating the coupling.

510-A.9.3.2 Mechanical Seal Inspection. Inspect the mechanical seal weekly. Operate idle pumps for 15 minutes to check for leakage through seal faces, mechanical seal gland gasket, and all flushing line connections. Mechanical seals are to operate with no leakage; a maximum leakage of 5 drops per minute is permitted. If a high leakage rate occurs, replace the worn or damaged seal components causing the leakage, per instructions in the pump technical manual.

510-A.9.3.3 Flexible Coupling Lubrication. Lubricate the flexible coupling quarterly as follows:

WARNING

Prior to working on equipment, place all switches and circuit breakers in the OPEN (OFF) position and tag: DANGER SHOCK HAZARD. Do not change position of switch except by direction of NAME...... RATE/RANK.

1. Remove coupling guard. Remove lube plugs on coupling flanges, and position lube holes at 45 degrees to horizontal.
2. Force grease (MIL-G-23549) into flange hole until clean grease flows out of the opposite hole.
3. Replace lube plugs and coupling guard.

510-A.9.3.4 Setup and Foundation Bolt Check. Check setup and foundation bolts quarterly as follows:

1. Inspect studs and nuts in pump casing to ensure tightness.
2. Secure screw taper pins on pump casing and pins on pump and motor feet.
3. Inspect tightness of holddown bolts.
4. Check torque of subbase-to-pump soleplate bolting.
5. Inspect tightness of foundation bolts from resilient mounts to unit soleplates and ship structure.

510-A.9.3.5 Pump Bearing Lubrication. Lubricate pump bearings quarterly as follows:

1. Remove pipe plugs from bottom of bearing brackets.
2. While pump is running, force new grease (MIL-G-24139) through bearing grease fittings until grease is forced from pipe plug openings in bearing brackets. Stop grease application immediately.
3. Replace pipe plugs.

510-A.9.3.6 Flexible Coupling Alignment Inspection. The flexible coupling should be cleaned and inspected, and its alignment checked semiannually. The indicator reverse method of alignment, as described in NAVSEA S6226-JX-MMA-010, **Indicator Reverse Method Of Pump Shaft Alignment** , is the preferred method of alignment. The inspection and alignment check is accomplished as follows:

WARNING

Prior to working on equipment, place all switches and circuit breakers in the OPEN (OFF) position and tag: DANGER SHOCK HAZARD. Do not change position of switch except by direction of NAME...... RATE/RANK.

1. Remove coupling guard, coupling bolts, nuts, O-rings, and gasket. Slide sleeve apart.
2. Clean out old lubricant, and inspect seals and gear teeth.
3. Check required spacing between coupling hubs per pump technical manual. Typical required spacing is 0.12 inch between pump and motor shafts. Measure spacing with a tapered feeler gauge at 90-degree intervals around the coupling.
4. If coupling hub spacing is not uniform at the proper value, align hubs by shifting or shimming the pump motor. To adjust the pump motor, remove taper pins from the motor feet, and loosen motor to baseplate bolts. Reposition motor to achieve proper hub spacing, tighten motor to baseplate bolts, and reinsert taper pins.
5. Axially align pump and motor as instructed in the installation chapter of the pump technical manual and in NAVSEA S6226-JX-MMA-010.
6. Reinstall sleeves over shaft ends. Take care not to damage O-rings.
7. Reinstall gasket, bolts, and nuts; and tighten bolts to required torque per pump technical manual. Typical torque value is approximately 40 foot-pounds.
8. Remove both lube plugs and position lube holes at 45 degrees to horizontal. Force grease (MIL-G-23549) into top hole until clean grease flows out of opposite hole. Reinstall lube plugs and coupling guard.

510-A.9.3.7 Motor Bearing Lubrication. This procedure applies to greasable bearings only; if the bearings are sealed, no lubrication is to be added. Lubricate motor bearings annually as follows:

1. Before greasing, wipe motor bearing grease fittings to remove all dirt and foreign matter. Apply grease with grease gun.
2. Remove the relief plugs from the bottom of the bearing housings, and clean out any hard grease in the openings.
3. With the motor running, add one to two ounces of grease per MIL-G-24139 or equal.

4. Reinstall relief plugs.

510-A.9.3.8 Motor Cleaning and Inspection. Clean and inspect motor annually as follows:

1. Keep the interior and exterior of the machines clean. Do not allow dirt and oil to accumulate either inside or outside of the machines.
2. Inspect all studs, nuts, and bolts and keep tight.

NOTE

The squirrel cage rotor requires no maintenance.

3. Clean the motor with a vacuum, using a nonmetallic tipped nozzle.
4. Clean the motor bearings if greasable bearings are installed; if there are sealed bearings, skip this step. Clean the bearings as follows:
   a. Remove drain plug from fitting or housing, and remove grease cup.
   b. Clean out grease in both drain and input to bearing chamber with a long, small screwdriver or similar tool.
   c. Flush light oil through the bearing chamber; rotate motor slowly by hand while flushing.
   d. Be sure the drain is open while flushing; flush the oil slowly to prevent it from entering the inside of the motor.
   e. Lubricate the motor bearings as described in paragraph 510-A.9.3.7.

510-A.9.3.9 Inspection of Pump Internal Parts for Wear. Inspect pump internal parts annually. Detailed procedures to be followed for pump disassembly and inspection, rotor disassembly and inspection, rotor assembly, and pump assembly are described in the technical manual. All warnings and cautions in the technical manual shall be followed.

510-A.9.3.10 Pump Mechanical Seal Replacement. The pump mechanical seal is designed to operate with no leakage. A maximum leakage of 5 drops per minute is permitted. If a higher leakage rate occurs, replace worn or damaged seal components causing the leakage. Consult the applicable pump technical manual corrective maintenance procedures for detailed instructions on how to replace the mechanical seal.

510-A.9.4 CHILLED WATER PUMP CORRECTIVE MAINTENANCE. Corrective maintenance procedures for the chilled water pump are contained in the applicable pump technical manual; the relevant procedures shall be studied and followed, along with the required warnings and cautions. Included in the corrective maintenance section of the pump technical manual are pump and motor balancing procedures, vibration measurement instructions, required alignment checks, and required adjustments. The pump repair procedures described in the pump technical manual include those for pump disassembly and assembly, rotor disassembly and assembly, pump bearing replacement, motor bearing replacement, pump casing wear ring replacement, mechanical seal installation, shaft sleeve replacement, flexible coupling replacement, and pump rotor balancing.

510-A.9.5 CHILLED WATER EXPANSION TANK. No routine maintenance is required for the chilled water expansion tank or its auxiliaries. Corrective maintenance may be required to replace items such as tank manhole gaskets; gauge glasses; relief valves; hose connections; and instrumentation such as pressure gauges, low level alarms, and low level equipment interlocks. Consult the appropriate equipment technical manual for maintenance instructions. Paragraph 510-A.8.7 describes expansion tank filling, draining, and adding air.

510-A.9.6 SYSTEM VENTING AFTER MAINTENANCE. Atmospheric air enters the chilled water system when a component is isolated, repaired, and reconnected to the system. The air should be vented from the chilled water system after the maintenance has been completed as described in paragraph 510-A.8.8.

510-A.10 TROUBLESHOOTING

510-A.10.1 TROUBLESHOOTING TABLES. Troubleshooting Table 510-A-1 through Table 510-A-5 list the following: the problems that may occur during operation of the chilled water system, system indications that accompany the given problems, probable causes, and corrective actions. In addition to these troubleshooting procedures, the AC plant and chilled water pump technical manuals contain complete troubleshooting procedures for all AC plant components, including the chiller and the chilled water pumps.

Table 510-A-1 CENTRIFUGAL PLANT CHILLER TROUBLESHOOTING

Problem or Indication	Probable Cause	Corrective Action
Low chiller refrigerant pressure - high chilled water and refrigerant temperature difference & high compressor discharge temperature	1. Insufficient refrigerant charge	1. Check for leaks and charge refrigerant into system.
Low chiller refrigerant pressure - high chilled water and refrigerant temperature difference & normal compressor discharge temperature	1. Chiller tubes dirty, fouled, or restricted	1. Check for dirty or fouled chiller tubes. Clean tubes.
Low chiller refrigerant pressure - low chilled water temperature & low compressor amps	1. Insufficient load	1. Check capacity control system.
		1. Check for correct manual load valve position. Check thermostat setting.
High chiller refrigerant pressure - low compressor discharge temperature	1. Liquid slugging; system overcharged	1. Check refrigerant charge. Remove refrigerant if necessary.
High chiller refrigerant pressure - high chilled water temperature	1. Prerotation vanes fail 2. System overloaded	1. Check function and settings of capacity control system. Check prerotation vanes operation. 2. Transfer cooling loads to other air conditioning plants. Ensure that prerotation vanes are wide open without motor overload.

Table 510-A-2 RECIPROCATING PLANT CHILLER TROUBLESHOOTING

Problem or Indication	Probable Cause	Corrective Action
Low chiller refrigerant pressure (compressor suction)	1. Insufficient refrigerant charge 2. Excessive superheat 3. Clogged screen strainer in compressor suction manifold 4. Improper operation of solenoid valve 5. Capacity control system unloading at too low of a suction pressure	1. Add refrigerant. 2. Adjust thermal expansion valve to 8° - 10°F superheat. 3. Pump system down; remove and clean screen strainer. 4. Examine solenoid coil for burnout; replace if needed. Check solenoid power supply. Check solenoid thermostat settings. 5. Adjust capacity control valve to begin unloading at a higher control point.
High chiller refrigerant pressure (compressor suction)	1. Overfeeding of thermal expansion valve 2. Leaking compressor suction valve 3. Capacity control system unloading at to high of a suction pressure	1. Adjust expansion valve. Check installation of thermal bulb. 2. Pump system down and remove cylinder heads. Examine valve discs and seats; replace if necessary. 3. Adjust capacity control system to begin unloading at a higher control point.

Table 510-A-3 CHILLED WATER PUMP TROUBLESHOOTING

Problem or Indication	Probable Cause	Corrective Action
Chilled water pump does not deliver liquid	1. Pump suction valve closed 2. Pump suction piping not completely filled with liquid (pump not primed)3. Low pump speed4. Pump discharge head too high5. Impeller passages partially clogged	1. Open pump suction valve. 2. Open vent valve and prime pump. Open pump suction valve(s). 3. Check that pump motor is receiving full voltage. 4. Open pump discharge valve. 5. Inspect impeller and remove obstructions.
Low flow capacity	1. Air leaks in pump suction piping 2. Low pump speed 3. High discharge head 4. Partially closed pump suction valve 5. Impellor passages partially clogged 6. Impeller damaged or badly worn 7. Casing rings badly worn 8. Defective gaskets	1. Check suction piping and sealing lines for air leaks. 2. Check that pump motor is receiving full line voltage. 3. Open pump discharge valve. 4. Open suction valve completely. 5. Inspect impeller and remove obstructions. 6. Replace impeller. 7. Replace casing rings. 8. Replace gaskets.

Table 510-A-3 CHILLED WATER PUMP TROUBLESHOOTING -

Continued

Problem or Indication	Probable Cause	Corrective Action
Low discharge pressure	1. Low pump speed 2. Air in liquid 3. Partially closed suction valve(s) 4. Worn impeller or casing rings	1. Check that pump motor is receiving full line voltage 2. Check pipe connections for leaks. Check that vent is closed. 3. Open suction valve(s) completely. 4. Replace impeller or casing rings.
Pump loses prime after starting	1. Leaking suction line 2. Partially closed suction line valve 3. Clogged suction line 4. Air or gases in liquid	1. Check for leaks and correct. 2. Open suction valve completely. 3. Remove suction line obstructions. 4. Check pipe connections for leaks. Check that vent is closed.
Pump overloads motor	1. Speed too high 2. High pump flow rate 3. Worn pump bearings	1. Check motor power supply characteristics 2. Check for excess pump flow and runout on pump performance curve. Throttle pump discharge to reduce flow. Check for open discharge piping. 3. Replace pump bearings.
Pump vibration	1. Pump and motor misalignment 2. Loose baseplate mounting 3. Pump cavitation 4. Rotating elements rubbing 5. Bent shaft 6. Worn bearings 7. Air in liquid	1. Check alignment. 2. Tighten foundation bolts. 3. Check for open suction valve and clogged suction. 4. Inspect rotating elements; replace or remachine. 5. Replace shaft. 6. Replace bearings. 7. Check that suction piping is open and vent is closed.
Motor will not start	1. No input power 2. Improper voltage 3. Short circuit4. Mechanical obstruction that prevents rotor from turning	1. Check controller connections. Check fuses and circuit breakers in controller cabinet or input circuit. Check power input source terminals. 2. Check voltage at motor terminals. 3. Check motor insulation resistance to ground. Check resistance between phases. 4. Remove obstruction. Check for bearing failure or misalignment. Check for bent shaft.

Table 510-A-3 CHILLED WATER PUMP TROUBLESHOOTING - Continued

Problem or Indication	Probable Cause	Corrective Action
Motor overheats	1. Motor overload 2. Unit operating at improper terminal voltage 3. Short circuit 4. Obstruction in air gap 5. Obstruction in ventilation 6. Insufficient cooling medium 7. Overgreased bearings 8. Improper grease 9. Misalignment	1. If measured phase current exceeds nameplate rating, reduce load on motor. 2. Check terminal voltage. 3. If phase voltage equals nameplate, check phase stator resistance. 4. Check for mechanical failure that prevents proper rotation. 5. Check that motor ventilation openings are clean and clear of obstructions. 6. Measure motor temperature. if it exceeds ambient temperature plus rated motor temperature rise, provide external cooling ventilation. 7. Check for proper bearing chamber grease amount per nameplate. Remove grease if needed. 8. Check for proper grease type. 9. Realign. Replace bearings or shaft, if needed.
Motor operating at wrong speed	1. Improper line voltage or frequency 2. Overload 3. Short circuit	1. Check nameplate data. 2. Check nameplate rating; reduce load. 3. Check rotor. Check for loose or open connections.

Table 510-A-4 CHILLED WATER EXPANSION TANK TROUBLESHOOTING

Problem or Indication	Probable Cause	Corrective Action
Motor vibration	1. Pump and motor misalignment 2. Sprung shaft 3. Short circuit 4. Unbalanced current 5. Improper mounting 6. Mechanical unbalance	1. Realign. Replace bearings if necessary. 2. Replace shaft.3. Check phase resistance. Check rotor. 4. Check motor controller terminal voltage and current. 5. Check pump, coupling, and motor mounting bolts and tighten if necessary. Align if necessary. 6. Check certification data for intended balance.
Deteriorated motor insulation	1. Oil-soaked windings 2. Water-soaked windings 3. Excessive vibration 4. Wrong voltage 5. Mechanical abrasion	1. Open motor; clean and dry windings. 2. Open motor; clean and dry windings. 3. See motor vibration problem and indication 4. Check terminal voltage against nameplate data. 5. Check for air gap misalignment, bearing failure, bent shaft, motor and pump misalignment, or air gap obstruction.

Table 510-A-4 CHILLED WATER EXPANSION TANK

TROUBLESHOOTING - Continued

Problem or Indication	Probable Cause	Corrective Action
Mechanical seal overheats	1. Clogged and crimped flushing lines 2. Obstructed separator passage 3. Excessive seal face pressure 4. Low liquid flow to seal	1. Locate and correct blockage. 2. Flush separator. 3. Verify proper axial location of seal components. 4. Do not cavitate pump or run at shutoff.
Mechanical seal leaks	1. Worn seal faces 2. Chipped and cracked carbon seal ring 3. Low seal face pressure	1. Replace worn seal parts. 2. Replace carbon seal ring. 3. Verify proper axial location of seal components.
Low water level	1. Chilled water system fluid leaks	1. Locate and repair leaks; add water to expansion tank.
High water level	1. Loss of expansion tank air pressure	1. Check expansion tank and valves for air leaks; repair leaks; recharge expansion tank to proper air pressure.
Low air pressure	1. Expansion tank valves, fittings leaks 2. Low water level	1. Locate, repair leaks; add air and water as needed. 2. Find cause of low water level; add water to expansion tank.
Leaking vent, drain, water fill, air charging, or gauge glass valves	1. Loose connections, worn gaskets and O-rings	1. Tighten connections; replace gaskets and O-rings as needed.
Leaking expansion tank relief valve	1. Worn spring, gaskets 2. Failure to reseat after lifting	1. Inspect, replace worn valve components. 2. Replace valve seat; retest valve.
Inoperable level sensors or alarms	1. Faulty level sensor 2. Faulty alarm circuitry	1. Replace sensor. 2. Troubleshoot and repair alarm circuits.

Table 510-A-5 CHILLED WATER EXPANSION TANK TROUBLESHOOTING

Problem or Indication	Probable Cause	Corrective Action
High chiller chilled water outlet temperature	1. Chiller malfunction 2. Chiller overloaded	1. See Table 510-A-1 or Table 510-A-2 2. Reduce chiller cooling load by transferring load to other AC plants or securing nonvital loads.
Low chiller chilled water outlet temperature	1. Chiller capacity control system malfunction 2. Low chilled water thermostat setting 3. Faulty low chilled water temperature cutout switch	1. See Table 510-A-1 or Table 510-A-2 2. Adjust thermostat setting to 45°F. 3. Check switch operation; repair or replace.
Chiller chilled water failure switch inoperative	1. Faulty switch	1. Check switch operation; repair or replace.

Table 510-A-5 CHILLED WATER EXPANSION TANK

TROUBLESHOOTING - Continued

Problem or Indication	Probable Cause	Corrective Action
Low chiller chilled water flow	1. Chilled water pump malfunction 2. Dirty and clogged chiller tubes (centrifugal chiller) 3. System isolation valves not fully open	1. See Table 510-A-3. 2. Clean tubes. See Table 510-A-1 3. Check that chiller, pump, and distribution system suction, discharge, and isolation valves are fully open.
Low chilled water pump discharge flow	1. Faulty chilled water flow meter 2. Chilled water pump malfunction 3. Clogged chiller tubes (centrifugal chiller) 4. Pump suction or discharge, distribution system isolation valves not fully open	1. Check flow meter; repair or replace. 2. See Table 510-A-3. 3. Clean tubes. See Table 510-A-1 4. Open valves fully.
High chilled water distribution system temperature	1. Chiller malfunction 2. Chiller overload	1. See Table 510-A-1 or Table 510-A-2 2. Reduce chilled cooling load by transferring loads to other AC plants or securing nonvital loads.
Faulty chilled water zone high temperature alarm	1. Faulty zone temperature switch	1. Check switch; repair or replace.
Low chilled water distribution system pressure	1. Chilled water pump malfunction	1. See Table 510-A-3
	2. High chilled water pump flow 3. Piping leaks	2. Reduce chilled water flow by securing nonvital loads. 3. Locate and repair leaks.
Faulty chilled water zone low-pressure alarm	1. Faulty zone pressure switch	1. Check switch; repair or replace.
Low chilled water zone flow rate	1. Low chilled water pump pressure due to pump malfunction or runout on pump performance curve 2. Piping leaks	1. Repair pump; see Table 510-A-3. Reduce chilled water flow by securing nonvital loads. 2. Locate and repair leaks.
Faulty chilled water zone low flow rate alarm	1. Faulty zone flow switch	1. Check switch; repair or replace.
High chilled water outlet temperature from cooling coils or heat exchangers	1. High cooling coil and heat exchanger chilled water inlet temperature 2. Poor heat transfer in cooling coil and heat exchanger	1. Check that chiller outlet temperature is 45°F or less. 2. Clean and vent cooling coil or heat exchanger.

Table 510-A-5 CHILLED WATER EXPANSION TANK

TROUBLESHOOTING - Continued

Problem or Indication	Probable Cause	Corrective Action
Reduced cooling coil or heat exchanger heat transfer	1. Fouled and dirty cooling coil tubes or heat exchanger tubes or shell 2. Dirty cooling coil fins 3. Bent and damaged cooling coil fins 4. Air blanket in cooling coil tubes or heat exchanger tubes or shell	1. Clean cooling coil tubes or heat exchanger tubes and shell. 2. Clean cooling coil fins. Replace ventilation system air filter. 4. Vent cooling coil inlet and outlet pipe, heat exchanger head, or shell to remove air.
Air in chilled water distribution system	1. Faulty automatic air vents 2. Failure to manually vent system if there are no automatic air vents	1. Repair or replace automatic air vents. 2. Manually vent system after system maintenance. Routinely vent system to remove air.

REAR SECTION

NOTE

TECHNICAL MANUAL DEFICIENCY/EVALUATION EVALUATION REPORT (TMDER) Forms can be found at the bottom of the CD list of books. Click on the TMDER form to display the form.